THE
POPULAR SCIENCE
MONTHLY

SEPTEMBER, 1907

THE PROBLEM OF AGE, GROWTH AND DEATH

By CHARLES SEDGWICK MINOT, LL.D., D.Sc.

JAMES STILLMAN PROFESSOR OF COMPARATIVE ANATOMY IN THE HARVARD MEDICAL SCHOOL

III. The Rate of Growth

Ladies and Gentlemen: In the first of the lectures, I described those grosser characteristics of old age, which we ourselves can readily distinguish, or which an anatomical study of the body reveals to us. In the second lecture I spoke of the microscopic alterations which occur in the body as it changes from youth to old age. But besides the changes, which we have already reviewed, there are those others, very conspicuous and somewhat known to us all, which we gather together under the comprehensive term of *growth*. It is growth which I shall ask you to study with me this evening, and I shall hope, by the aid of our study, to reinforce in your minds the conclusion which I have already indicated, that the early period of life is a period of rapid decline, and that the late period of life is one of slow decline.

In order to study growth accurately, it is desirable, of course, to measure it, but since we are concerned with the general problem of growth, we wish no partial measure, such as that of the height alone would be. And indeed, if we take any such partial measure, how could we compare different forms with one another? The height of a horse is not comparable to that of a man; the height of a caterpillar is not comparable to that of any vertebrate. Naturally, therefore, we take to measuring the weight, which represents the total mass of the living body, and enables us at least with some degree of accuracy to compare animals of different sorts with one another. Now in studying this question of the increase of weight in animals, as their age increases, it is obviously desirable to eliminate from our experiments all disturbing factors which might affect the rate of growth or cause it to assume irregularities which are not inherent either in the organiza-

tion of the animal or in the changes age produces. The animals which belong to the vertebrate sub-kingdom, of which we ourselves are members, can be grouped in two large divisions according to the natural temperature of their bodies. The lower vertebrates, the fishes, frogs and their kin, are animals which depend for their body temperature more or less on the medium in which they live. The other division of vertebrate animals, which includes all the higher forms, are so organized that they have within certain limits the power of regulating their own body temperature. Now it is easily to be observed—and any one who has made observations upon the growth of animals can confirm this—that animals otherwise alike will grow at different speeds at different temperatures. There are animals, like the frogs and salamanders, which will live at a very considerable range of temperature and thrive, apparently. No ultimate injury is done to them by a change of their bodily temperature. Here we have a picture of four young tadpoles, all of which are exactly three days old. The first of these has been kept at a temperature not much above freezing. The fourth, at a temperature of about 24 degrees centigrade; the other two at temperatures between. They are all descendants from the same batch of frogs' eggs, and you can see readily that the first one is still essentially nothing but an egg. The second one, which has had a little higher temperature, already shows some traces of organization, and those familiar with the development of these animals can see in the markings upon the surface the first indications of the differentiation of the nervous system. The third has been kept at a considerably warmer temperature, and is now obviously a young tadpole; here are the eyes, the rudimentary gills, the tail, etc. While the fourth tadpole, which was maintained at the best temperature for the growth of these animals, has advanced enormously in its development. Obviously, should we make experiments upon animals of this class it would be

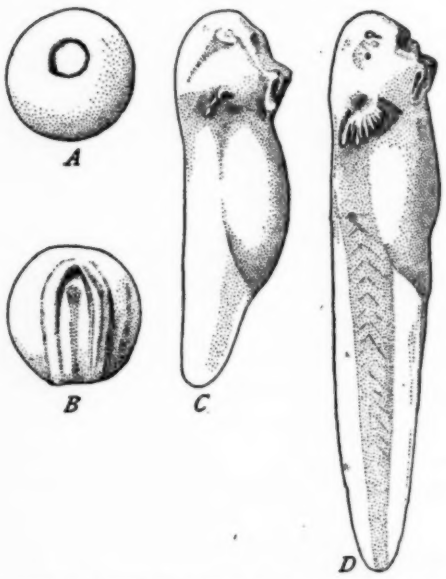


FIG. 19. FOUR TADPOLES OF THE EUROPEAN FROG *Rana fusca*. After Oskar Hertwig. The four animals are all of the same age (three days) and raised from the same batch of eggs, but have been kept at different temperatures.

A at 11.5° Centigrade. *B* at 15.0° Centigrade.
C " 20.0° " *D* " 24.0° "

necessary to keep them at a uniform temperature, if we wished to study their rate of development, and that is, for very practical reasons, extremely difficult and unsatisfactory. Far better it has seemed for our study of growth to turn to those animals which regulate their own temperature. This, accordingly, I have done, and the animal chosen for these studies was the guinea-pig, a creature which offers for such investigations certain definite advantages. It is easily kept; it is apt to remain, with proper care, in good health. Its food is obtainable at

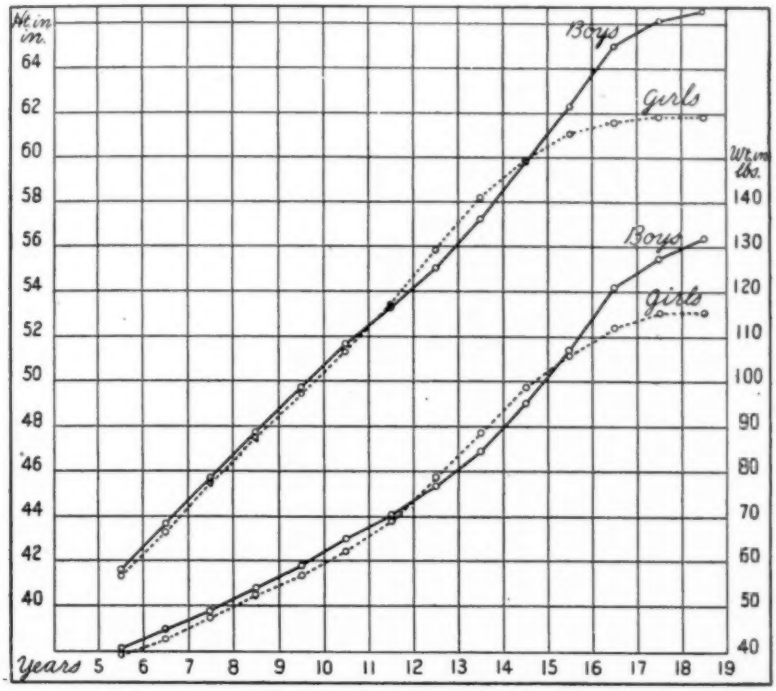


FIG. 20. CURVES SHOWING THE GROWTH OF BOSTON SCHOOL CHILDREN IN HEIGHT AND WEIGHT. After H. P. Bowditch.

all seasons of the year, in great abundance, and at small expense. The animals themselves being of moderate size do not, of course, require such extraordinary amounts of food as the large animals, should we experiment with them. Accordingly with guinea-pigs I began making, years ago, a long series of records, taking from day to day, later from week to week, and then, as the animals grew older, month by month, the weight of recorded individuals. There was thus obtained a body of statistics which rendered it possible to form some idea of the rapidity of growth of this species of mammal.

Now in regard to the rapidity of growth, it is necessary that we form clearer notions than perhaps you started out with when you came into the hall this evening. I will ask for the next of our pictures on the screen, where we shall see illustrated to us older methods of

recording the progressive growth of animals. This is a chart taken from the records of my friend, Dr. Henry P. Bowditch, showing the growth of school children in Boston. Here we have, in the lower part of the figure, the two curves of growth in weight. The upper curve is the weight of boys. We can follow it back through the succession of years down to the age of five and one half years, when the records begin. The child weighs, as you see, a little over forty pounds at that time. When the boy reaches the age of eighteen and one half years, he approaches the adult size, and weighs well over 130 pounds. Here then we see growth represented to us in the old way, the progressive increase of the animal as it goes along through the succession of years. Now this is a way which records the actual facts satisfactorily. It shows the progressive changes of weight as they really occur; but it does not give us a correct impression of the *rate* of growth. Concerning the rate of growth, some more definite notion must be established in our minds before we can be said to have an adequate conception of the meaning of that term. It is from the study of the statistics of the guinea-pigs, and of other animals, which I have since had an opportunity of experimenting with, that we get indeed a clearer insight as to what the rate of growth really is and really means.

I should like to pause a moment to say that when I first published a paper upon the subject of growth, it, fortunately for me, interested the late Dr. Benjamin Gould. The experiments which I had made and recorded in that first publication came to a sudden end, owing to a disaster for which I myself was personally not responsible, by which practically my entire stock of animals was suddenly destroyed. Dr. Gould, after consulting with me, proposed that I should have further aid from the National Academy of Sciences, and through his intervention I obtained a grant from the Bache fund of the academy. That liberal grant enabled me to continue these researches, and this is the first comprehensive presentation of my results which I have attempted. In this and the subsequent lectures, I hope that enough of what is new in scientific conclusions may appear to make those to whose generosity I am indebted feel that it has been worthily applied. I can not let such an occasion as this pass by without expressing publicly my gratitude to Dr. Gould for his encouragement and support at a time when I most keenly appreciated it.

If animals grow, that which grows is of course the actual substance of the animal. Now we might say that given so much substance there should be equal speed of growth, and we should expect, possibly, to find that the speed would be more or less constant. I can perhaps illustrate my meaning more clearly, and briefly render it distinct in your minds, by saying that if the rate of growth, as I conceive it, should remain constant, it would take an animal at every age just the same length of time to add ten per cent. to its weight; it would not be a

question whether a baby grew an ounce in a certain length of time, and a boy a pound in the same time, for the pound might not be the same percentage of advance to the boy that the ounce would be to the baby. In reality with an advance of an ounce the baby might be growing faster than the older boy with the addition of the pound.

In the next slide which we are to have thrown upon the screen we have my method of measuring rate of growth illustrated graphically. There is here a curve which represents the rate of growth of male guinea-pigs. The figures at the bottom indicate the age of the animals in days. When guinea-pigs are born, they are very far advanced in development, and the act of birth seems to be a physiological

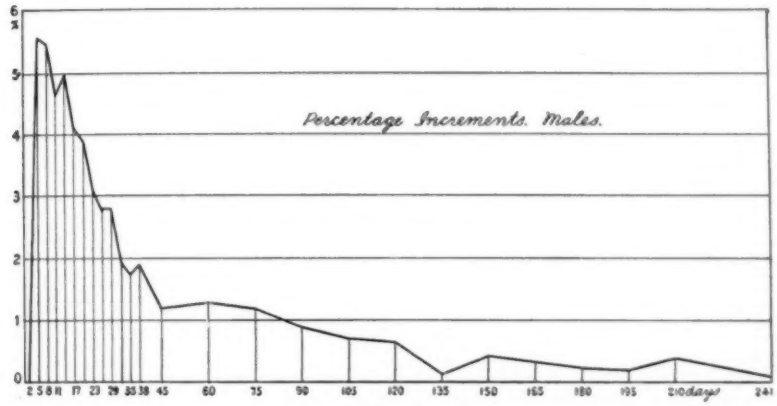


FIG. 21. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT OF MALE GUINEA PIGS.

shock from which the organism suffers, and there is a lessening of the power of growth immediately after birth. But in two or three days the young are fully recovered, and after that restoration they can add over five per cent. to their weight in a single day. But by the time they are 17 days old, as represented by this line, they can add only four per cent., and by the time they are 24 days old, less than two per cent.; at 45 barely over one per cent.; at 70 still over one per cent.; at 90 less; at 160 less; and towards the end the curve continues dropping off, coming gradually nearer and nearer to zero, to which it closely approximates at the age of 240 days. In about a year, the guinea-pig attains nearly its full size. You notice that this curve is somewhat irregular. Such is very apt to be the result from statistics when the number of observations is not very large. It means simply that there was not a sufficiently large number of animals measured to give an absolutely even and regular set of averages. But the general course of the curve is very instructive. In the earlier condition of the young guinea-pig there is a rapid decline; in the later, a slow decline.

The change from rapid to slow decline is not sudden, but gradual, as you see by the general character of this curve.

In the next slide we can see immediately that what I have asserted as true of the male is equally true of the female, although the values

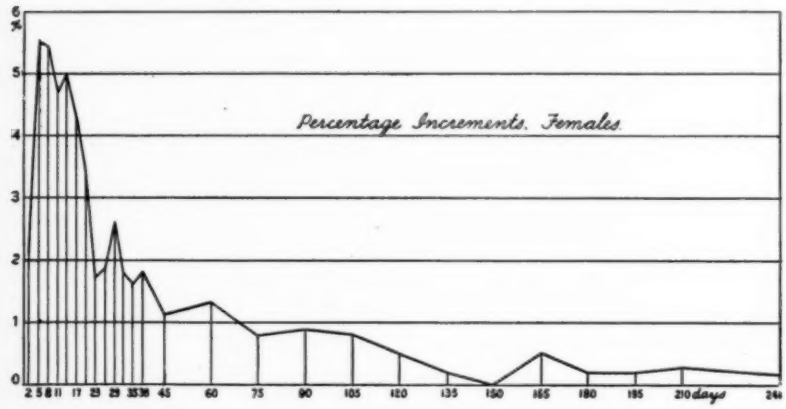


FIG. 22. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT OF FEMALE GUINEA-PIGS.

which we have differ slightly in the two sexes, and there are accidental but not significant variations in this curve as in the first. Here also we observe at once an early period of rapid decline in which the rate of growth is going down and down—a period of slight decline in which, to be sure, it is going down still, but with diminished rapidity.

There is another method by which we can represent this change

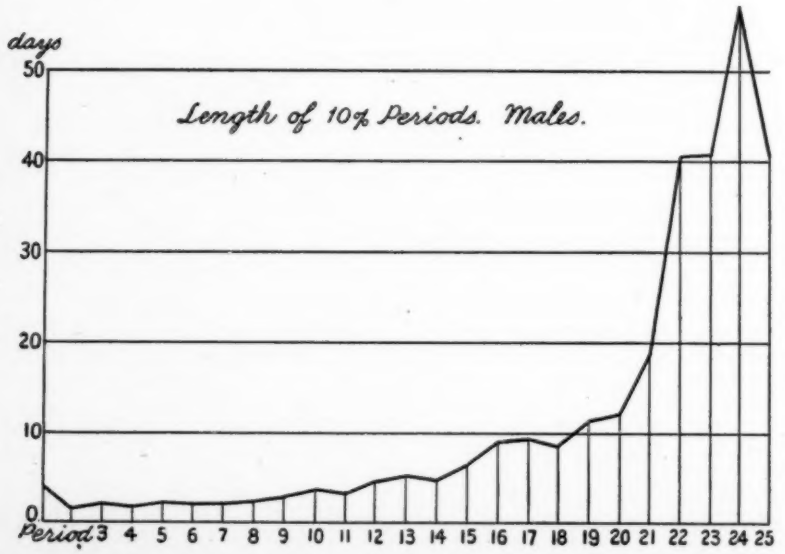


FIG. 23. CURVE SHOWING THE LENGTH OF TIME REQUIRED TO MAKE EACH SUCCESSIVE INCREASE OF 10 PER CENT. IN WEIGHT BY MALE GUINEA-PIGS.

in the rate of growth which will perhaps help to illustrate it; and in the next of our pictures we see this other form of representation before us. This vertical line represents the length of time which it takes a young male guinea-pig to add ten per cent. to its weight the first time. Here the third time—the fourth—the fifth—and you see as it is growing older and older it takes the animal longer and longer to add ten per cent. to its weight. Finally we get to the nineteenth addition, and we see that the period is very long indeed. How long that period is we can judge by the figures here upon the left, which represent the length of the days. From the base line to this one marked "ten" is a period of ten days, and you see from the time the guinea-pig has added to its weight ten per cent. for the nineteenth time it does it so slowly that it requires ten days and more; for the twenty-first time, nearly twenty; for the twenty-second time, nearly forty. Here where the number of observations becomes small, the curve grows very irregular. Thus we demonstrate that as the animal grows older it takes longer and longer to add ten per cent. to its weight. In the other sex, as the next slide shows, the same phenomena can be clearly demonstrated; here are the periods as before, lengthening out, as you see, at first; then becoming very long indeed. In the following slide I have another

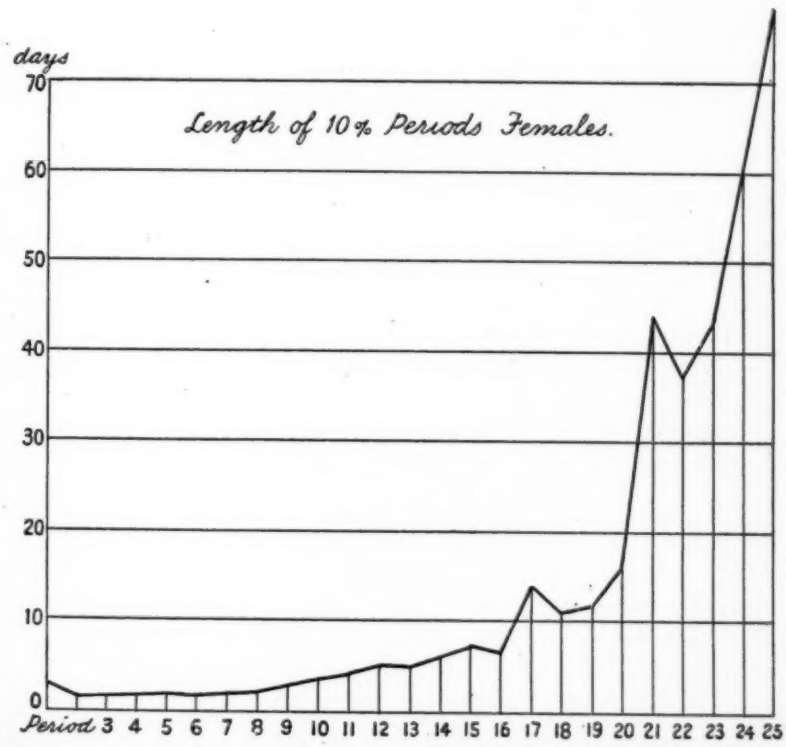


FIG. 24. CURVE SHOWING THE LENGTH OF TIME REQUIRED TO MAKE EACH SUCCESSIVE INCREASE OF 10 PER CENT. IN WEIGHT BY FEMALE GUINEA-PIGS.

form of representation of this same phenomenon as it occurs in the human subject. Here is a diagram of growth, which represents, as accurately as I could determine it, the curve complete for man from the date of birth up to the age of forty years. It has been calculated by a simple mathematical process where these ten-per-cent. increments fall, and from each point in this curve where there has been such an increment, a vertical line has been drawn, as you see here. These lines are very close together at the start. One ten per cent. after another follows in a short interval of time, but gradually the time, as indicated by the space between two of these vertical lines, increases, and when the individual is three years old, you can see there has been a very great

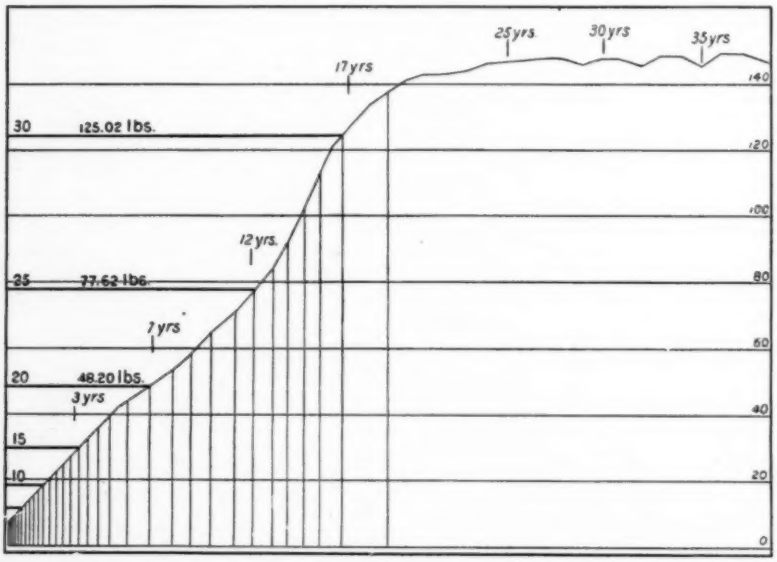


FIG. 25. CURVE SHOWING THE GROWTH OF MAN FROM BIRTH TO MATURITY, with vertical lines added to mark the duration of the periods, for each 10 per cent. addition to the weight.

lengthening out of the period which is necessary for it to add ten per cent. to its weight. Then it comes at the age of twelve to a period of slightly more rapid growth, a fluctuation which is characteristic of man, but does not appear in the majority of animals. After that comes very rapidly the enormous lengthening of the period; and I have not added the last ten per cent. because the curve here at the top, you see, is not very regular, and it could not be calculated with certainty. Our diagram is merely another form of graphic representation of the fact that the older we are the longer it takes us to grow a definite proportional amount.

The next slide carries us into another part of our study, away from the mammals which we have thus far considered, into the class of birds. The growth of chickens is represented here. Now a chicken is born in a less matured state than a guinea-pig, and has a good deal

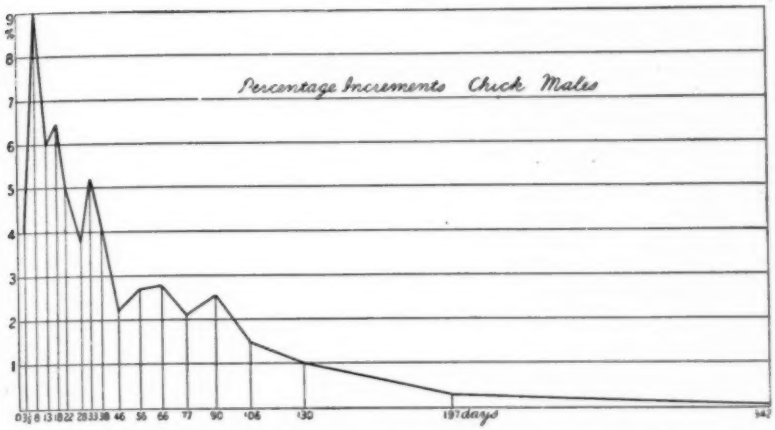


FIG. 26. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT BY MALE CHICKENS.

higher efficiency of growth at first. In a chicken, as in a guinea-pig, birth is a disturbing factor, and growth immediately after the hatching of the chicken is a little impeded, but the chick quickly recovers and, as we see, the first time when the rate can be distinctly measured we get a nine-per-cent. addition to the weight in a single day. In a chicken as in the guinea-pig, the rate gradually diminishes. The change from the rapid decline at first to the later slower decline is more gradual; the curve is more distinctly marked in the chicken as a round curve. There is not in the bird so marked a separation of the preliminary rapid decline and the later slower decline as we find in the guinea-pig. The curve again is very irregular because I had only a very limited number of observations upon the weight of chicks. The other sex, as the next slide will show, presents similar phenomena, though the female chickens do not grow quite as fast as their brothers. Here we notice an increase

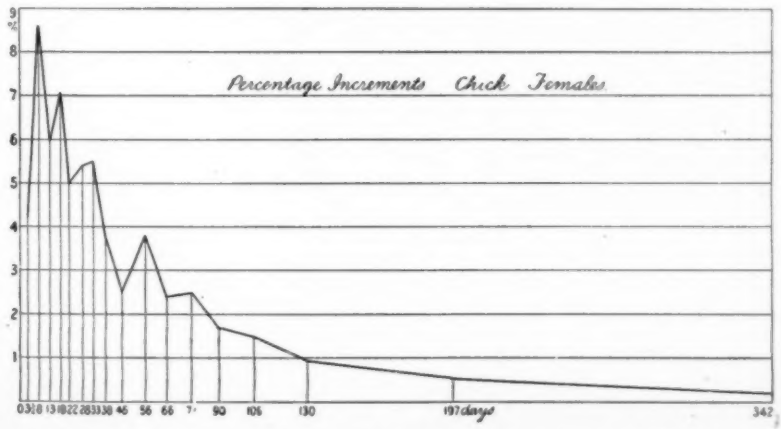


FIG. 27. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT BY FEMALE CHICKENS.

of almost, but not quite nine per cent., rapidly falling down so that after the chick is two months old it never adds as much as three per cent. to its weight. It loses in the first two months from a capacity to add nine per cent., down to a capacity of adding less than three. It loses in two months two thirds of its total power of growth, for from nine to zero is divisible into two parts, of which the first, from nine down to three, would be two thirds, and the second, from three to zero, would be one third. Here then we learn that two thirds of the decline which occurs in the life of a chick takes place in two months, and for the rest of the life of the bird there is a decline of one third. That, you must acknowledge, is an extraordinary and most impressive difference. If it be true that the more rapid growth depends upon the youth of the individual,—its small distance in time from its procreation, then we may perhaps, by turning to other animals which are born in a more immature state, get some further insight into these changes; and that I have attempted to do by my observations upon the development of rabbits. Rabbits, as you know, are born in an exceedingly immature state. They are blind, they are naked, they are almost incapable of definite movements, quite incapable of locomotion, and are hardly more than little imperfect creatures lying in the nest and dependent utterly upon the care of the mother, quite unable to do anything for themselves except take the milk which is their nourishment. They are indeed animals born in a much less advanced stage than are the guinea-pigs. Upon the screen we see this interesting result demonstrated to us, that a male rabbit, the fourth day after its birth, is able to add over seventeen per cent. to its weight in one day. From that the curve drops down, as you see, with amazing rapidity, so that here at an age of twenty-three days the rabbit is no longer able to add nearly eighteen per cent. daily, but only a little over six. At the end of two months from its birth, the growth power of the rabbit has dropped to less than two per cent., and at two months and a half it has dropped to one. The drop in two and a half months has been from nearly eighteen per cent. down to one per cent., and the rest of the loss of one per cent. is extended over the remaining growing period of the rabbit. Could we have a more definite and certain demonstration of the fact that the decline is most rapid in the young, most slow in the old? It is not in this case any more than in the others the one sex that demonstrates this fact, for in the female we find exactly the same phenomena, as the next slide will show. The irregularities are not significant. The strange dip at thirty-eight days, for instance, corresponds to an illness of some of the rabbits which were measured, but they rapidly recovered from it and grew up to be fine, nice rabbits. If instead of measuring half a dozen rabbits, we had measured two hundred or five hundred, these irregularities would certainly have disappeared. The females in the case of the rabbits, as in the case of the guinea-pigs, are not able

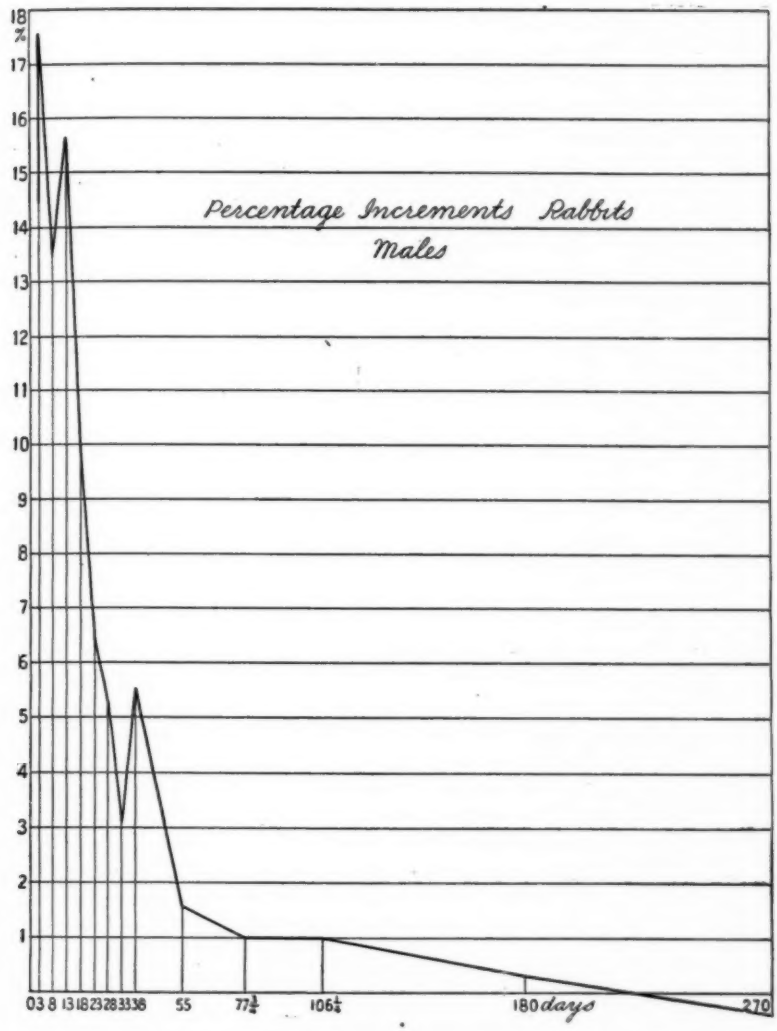


FIG. 28. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT BY MALE RABBITS.

to grow quite so fast at first. We see here sixteen instead of over seventeen per cent. as the initial value, but the general character of the drop is the same, enormously rapid at first and very slow afterwards. All of our cases, then, show the same fundamental phenomena appearing with different values.

Now in regard to man, we do not possess any such adequate series of statistics of growth as is desirable. We have many records of the weight of babies, by which I mean children from the date of birth up to one year of age. We have also very numerous records of school children, which will extend perhaps from five and one half up to say seventeen, eighteen or even nineteen years. There are records of boys

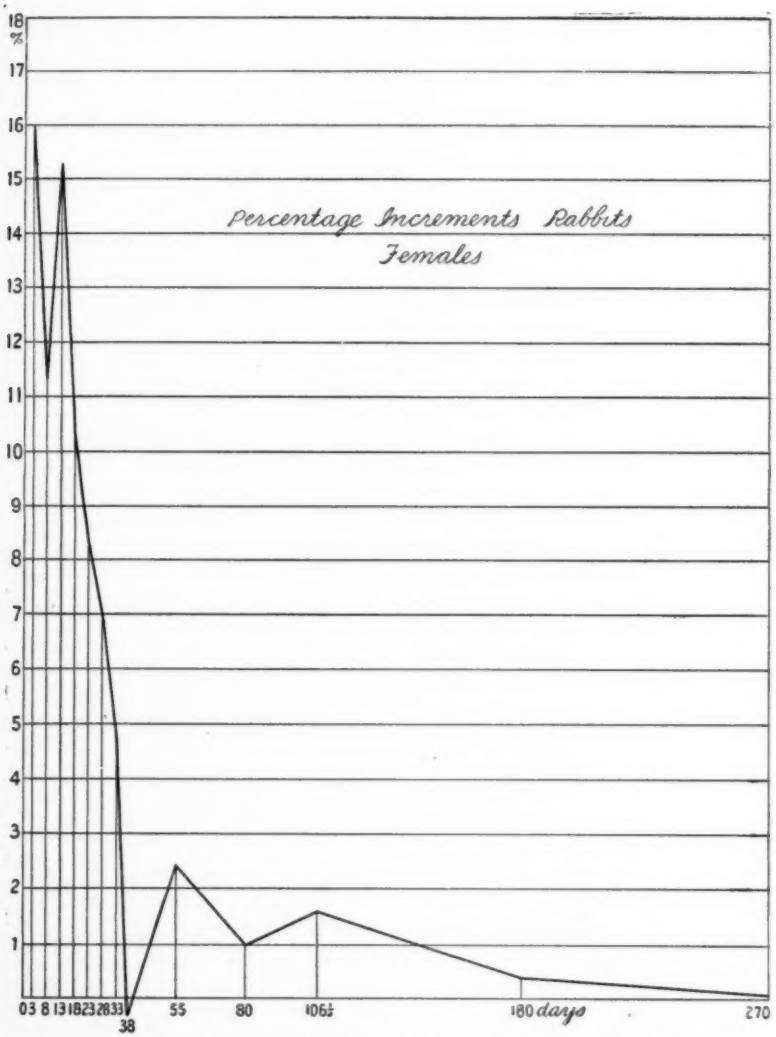


FIG. 29. CURVE SHOWING THE DAILY PERCENTAGE INCREMENTS IN WEIGHT BY FEMALE RABBITS.

at universities, and a still more limited number of weighings of girls at colleges. But all these statistics piled together do not give us one comprehensive set of data including all ages. This is very much to be regretted, and it would be an important addition to our scientific knowledge could statistics of the growth of man be gathered with due precautions. It would fill one of the gaps in our knowledge which is lamentable. We have, however, some rough, imperfect data which for our present purposes it seems to me are adequate, and the results of the study of these will be shown by the next series of pictures.

But let us pause for a moment to consider this singular table. It shows in this column the number of days which it takes for each species

TABLE[1]

Species	Days Needed to Double Weight	100 Parts Mother's Milk Contain			
		Proteid	Ash	Lime	Phosphoric Acid
Man	180	1.6	0.2	0.0328	0.0473
Horse	60	2.0	0.4	0.124	0.131
Cow	47	3.5	0.7	0.160	0.197
Goat	19	4.3	0.8	0.210	0.322
Pig	18	5.9	—	—	—
Sheep	10	6.5	0.9	0.272	0.412
Cat	9½	7.0	1.0	—	—
Dog	8	7.3	1.3	0.453	0.493
Rabbit	7	10 4	2.4	0.8914	0.9967

of animal indicated at the left to double its weight after birth. A man requires 180 days to double his weight; a horse, 60; a cow, 47; a goat, 19; a pig, 18; a sheep, 10; a cat, 9½; a dog, 8; a rabbit, 6 (or possibly 7 days). Now here are analyses of the milk. The main point of interest is to be found in the figures in this column, which represent the amount of albuminoid, or proteid material contained in the milk. You will observe that for man the proportion is lowest, 1.6 per hundred parts; the horse has a little more—2; cattle—3.5; and so the values run. In other words, it is obvious that the less the proteid in the milk, the longer does the species require to double its weight. This looks at first sight as if there were a relation between the composition of the milk and the period of growth of the animal; but you know very well that if you take the milk of a cow, which is very much richer in proteid material, and feed it to a baby, a human baby, that baby does not grow at the same rate as the young cow, but grows at the human rate. It is obvious, therefore, that it is somewhat more complicated than a mere question of food supply. We have in fact one of the beautiful illustrations of the teleological mechanism of the body. These various species have their characteristic rates of growth, and by an exquisite adaptation, the composition of the mother's milk has become such that it supplies the young of the species each with the proper quantum of proteid material which is needed for the rate of growth that the young offspring is capable of. It is a beautiful adjustment, but there is not a causal relation between proteid matter and this rate of growth. It is an example of correlation, not of causation.

We pass now to the next of our slides, which carries us over into the study of our own species. It is not possible at the present time to represent in any form of curve which I have seen the daily percentages of increment for man covering the whole period of growth. In order to get the results together, I have confined myself here to the representation of the yearly percentages. Now from the age of zero to the age of one year, you see according to this table a child is able to increase its weight 200 per cent. But from the beginning of the first to

[1] After Abderhalden, *Zeitschrift für Physiologische Chemie*, Band XXVI., p. 497.

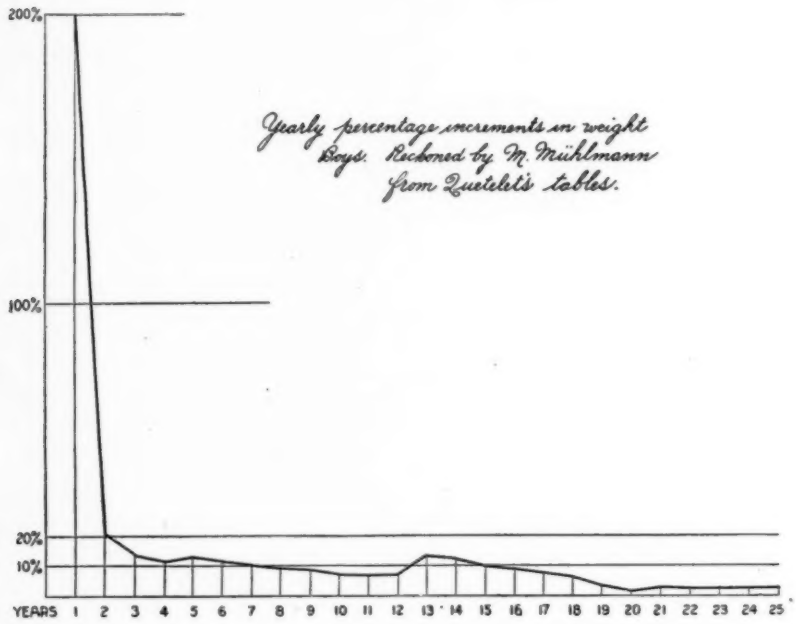

200%
100%
20%
10%
YEARS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Yearly percentage increments in weight
Boys. Reckoned by M. Mühlmann
from Quetelet's tables.

FIG. 30.

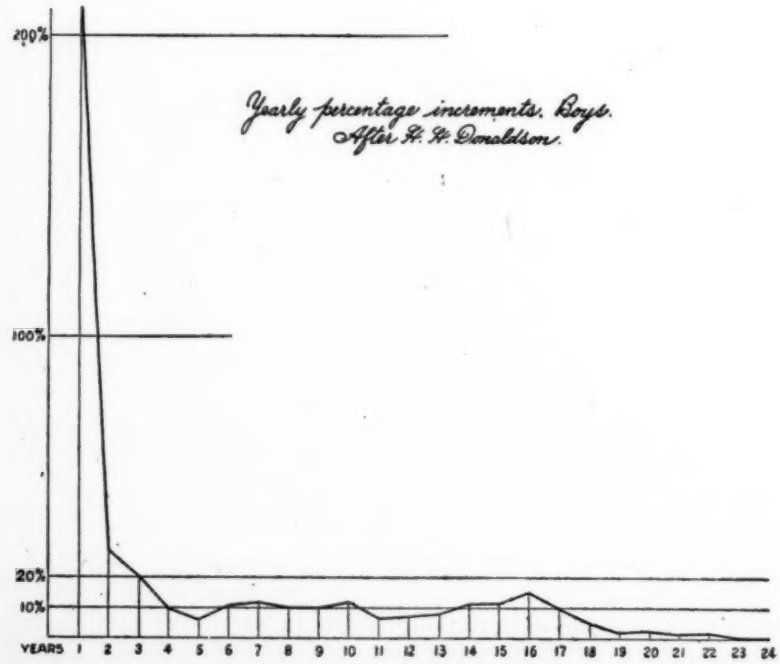

200%
100%
20%
10%
YEARS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Yearly percentage increments. Boys.
After H. H. Donaldson.

FIG. 31.

the end of the second year, only 20 per cent., and thereafter it fluctuates in the neighborhood of 10 per cent. a year until the age of 13. At 14 or 15 there is a fluctuation, an increase, and then the decline goes on again and slowly we see the growth power fading out. Authors are not agreed as to the exact statistical value, and so I will ask to have thrown upon the screen another curve, also representing the percentage increase of boys, and based chiefly upon English tables. For these data I am indebted to my friend Professor Donaldson, of the Wistar Institute in Philadelphia. He finds in these records an increment of a little more than 200 in the first year, but the drop comes during the second year and is startling in its enormous extent and is contrasted with the later less decline. The phenomena may well arouse our attention and convince us that we are approaching a most important scientific question, the question of why the drop comes in this way. In the case of girls, as the next of our slides will show, we can prove the same phenomena with slightly different values. Girls, like the females of other species, grow a little less forcibly, so to speak, than boys. They do not quite

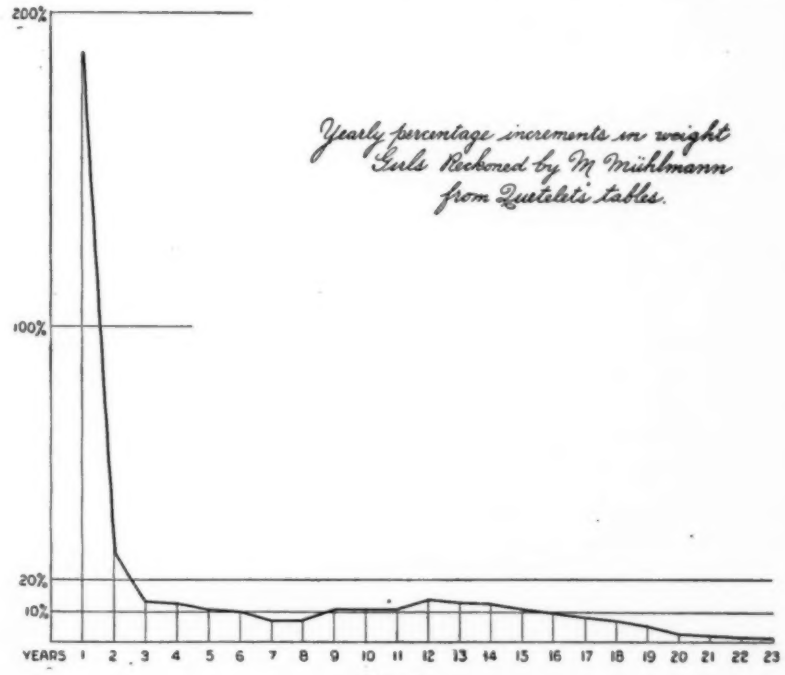

Yearly percentage increments in weight
Girls Reckoned by M Mühlmann
from Quetelet's tables.
200%
100%
20%
10%
YEARS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

FIG. 32.

attain a 200 per cent. value for the first year, but they too drop in a similar manner to the boys to about 30 per cent., and away down towards 10 per cent. in the third year. Then comes the long slow gradual decline up to the period of twenty-three. Professor Donaldson, as our next slide will demonstrate to us, has prepared curves from the English figures for girls also. They come up nearer to the 200 per

cent. than in Mühlmann's table, but drop well below 30 per cent. in the second year, and down to 20 per cent. in the fourth. Then occurs the slight increase of growth in the period of twelve, thirteen, fourteen years, and next the final stage of decline. In the four cases the human rate curve is similar. The great fall takes place at the beginning, the slow fall towards the end. Professor Thoma has thought he could get somewhat more accurate results by putting boys

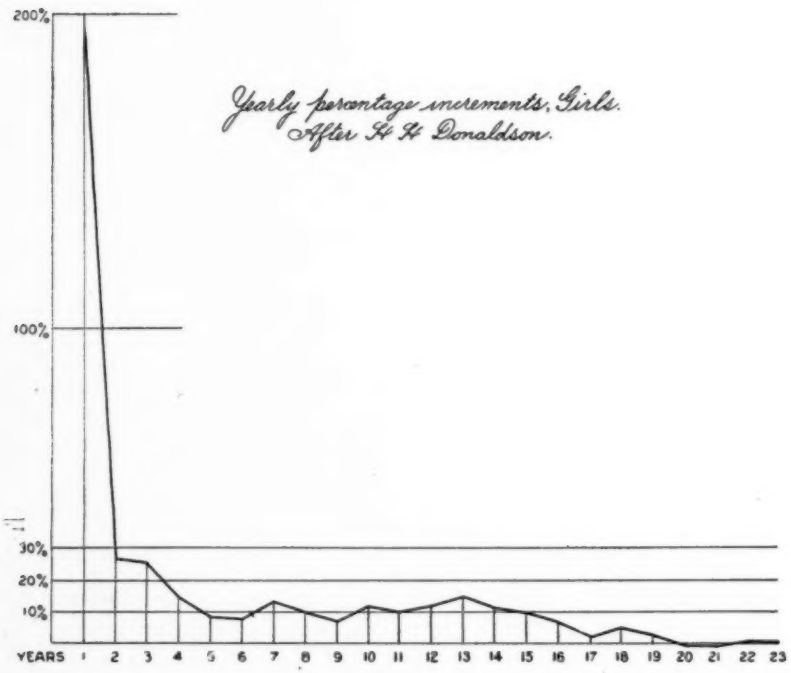

200%
100%
30%
20%
10%
YEARS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Yearly percentage increments. Girls.
After G. H. Donaldson.

FIG. 33.

and girls together, and he has made a calculation, as shown now upon the screen, of a curve in which the two sexes are combined. His figures again differ somewhat from those we have considered, but you meet in this curve also the same general phenomena. There is an enormous percentage of growth during the first year; an enormous drop during the second; then the slow decline; the moderate fluctuation upward; and then the last slow disappearance of growth. In every instance, therefore, we have an absolute demonstration, it seems to me, of the strange phenomenon. Paradoxical it will sound, whenever it is first stated to any one, that the period of youth is the period of most rapid decline; that the period of old age is that in which decline is slowest. We shall learn in the next lecture that this double phenomenon furnishes us a clue to further investigations, and leads to certain new inquiries, which enable us to gain some further insight into the essential nature of the phenomena of age.

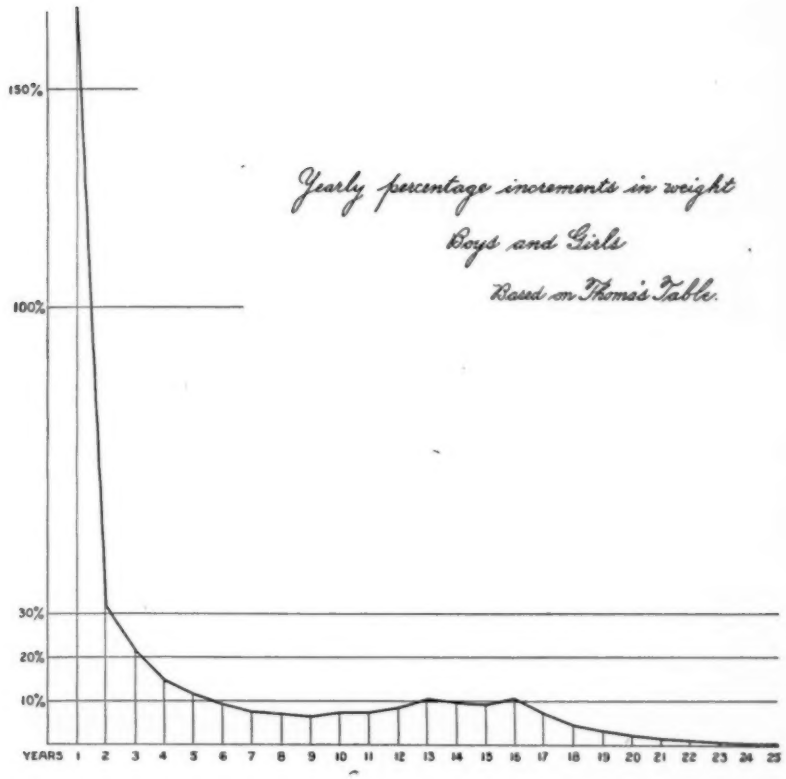

150%
100%
30%
20%
10%
YEARS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Yearly percentage increments in weight
Boys and Girls
Based on Thoma's Table.

FIG. 34.

This completes the series of curves which I had prepared to present to you to show the rate of growth in animals from their birth only, but of course there has been also a growth of the animals which preceded their birth, and that now must briefly be considered.

The mere inspection of developing embryos of known ages gives us some idea of the rate of growth. With the aid of the lantern I will ask you to look with me at some pictures of the developing chick and developing rabbit. Let us begin with the chick.[2]

[2] During the lectures a series of lantern slides were projected upon the screen, made from photographs of mounted specimens of chicken embryos, which showed very clearly the progress of development in the chick during the very early stages. The first figure illustrated a chick of 18 hours' incubation. The embryo had been skimmed off from the surface of the egg, hardened, colored artificially and mounted in the manner of the ordinary microscopical preparation in Canada balsam. At this age the naked eye can just distinguish a line, which indicates the position of the axis of the embryo. The unaided eye can recognize nothing more. In the second picture the head and neck of the embryo were easily distinguishable, and a few of the earliest primitive segments. The third slide showed a stage of a day and a half. The spinal cord and brain were distinctly differentiated, and numerous so-called "blood islands" scattered about.

We have first an embryo of twenty hours of incubation; following it one of one day. You can observe just a little line of structure indicated and showing where the longitudinal axis is to be situated. By the second day the chick has distinctly a head and a little heart, and those who are expert can differentiate with a microscope the axis of the body, the beginning of the formation of the intestine and of the muscles. At the end of the first day there was little more than a mere gathering of cells, but during the twenty-four hours of the second day the gathering has changed from a mere streak upon the surface of the yolk to a well-formed individual, with recognizable parts and several times the volume it had when one day old. The next figure illustrates the alteration which occurs during, approximately, the third day. It is obvious that the embryo has again made an enormous increase in volume. The eye has developed, the heart has become large, the tail is projecting, the dorsal curve of the future neck is distinguishable. We pass next to the fourth day. Is it not a strange looking beast, with its wing here and leg there, a little tail at this point; an enormous eye, almost monstrous in proportion; and, finally, here a bit of the brain. After five days we have a chick the brain of which is swelling, causing the head to be of so queer a shape that, with the eye, which seems out of all proportion to the rest of the body, it imparts an uncanny look to the embryo. The wing is shaping itself somewhat, and the ends of the leg, we can see, will, by expansion, form a foot. Finally, the chick after seven and after eight days is figured. In the short interval of only six days the chick grows from the size represented by Fig. 2 to that shown in the last figure upon the plate. It is an enormous increase. Suppose a chick after it was born were to grow at such a rate as that! The eight-day embryo is thirty or forty times as big as it was eight days before. It would seem marvelous to us if a chick after it was hatched should become in eight days thirty times as large and heavy as when it first came out from the egg. It is perhaps advisable to let you follow the growth of the chick a little farther, and accordingly I present another picture which shows an embryo of about ten days. The little marks upon the surface of these embryos indicate the commencing formation of the feathers. A comparison of the series of figures proves that the development is taking place with marvelous speed. We need only to look at these stages, comparing them with one another, to realize that the progress of the embryo in size and development occurs with a rapidity which is never to be found in later stages.

The history of embryonic rabbits declares with equal emphasis that the earliest development is extremely rapid. I wish now to show you

---

The final slide of the series showed a chick of three and one half days. It has not seemed necessary to reproduce these figures with the present text, as they merely duplicate, on a larger scale and with more detail, the pictures which have been included.

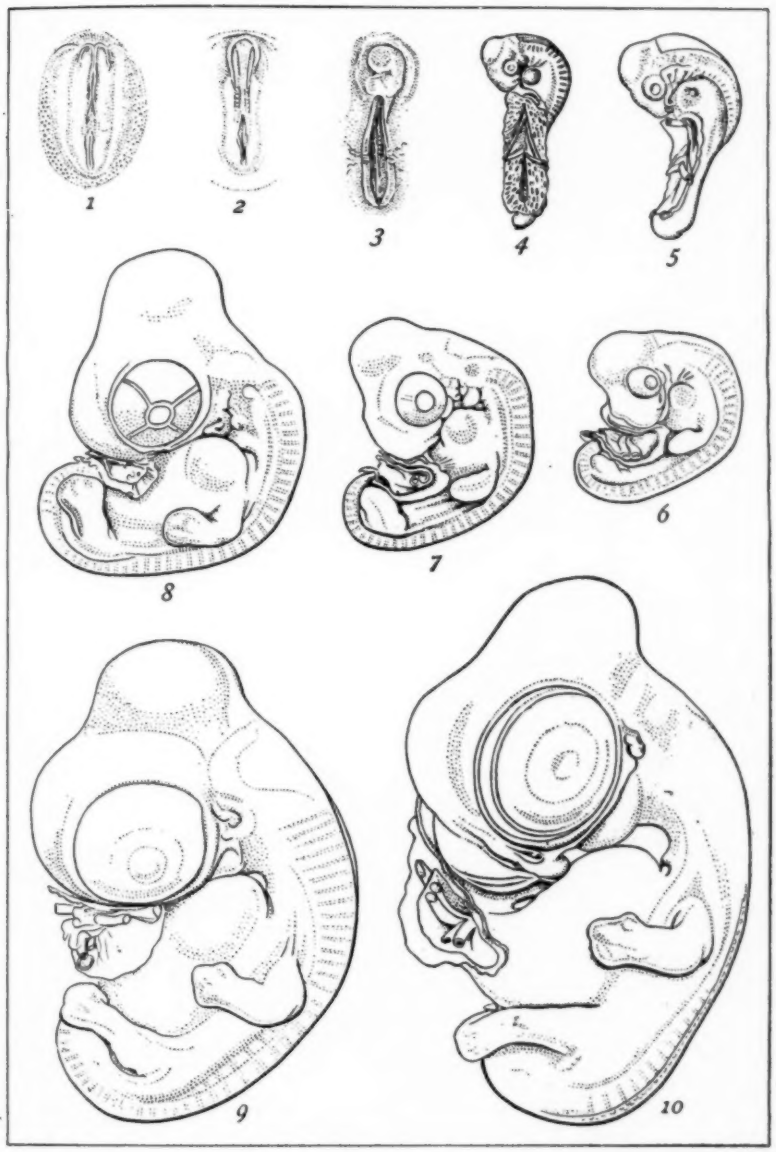


FIG. 35. TEN STAGES OF THE DEVELOPING CHICK, after Franz Keibel. All the figures are magnified four diameters. In No. 1 only the parts indicated in the vertical axis of the figure correspond to embryonic structures proper.

No. 1.	Incubated	20 hrs.	No. 6.	Incubated	3 days, 16 hrs.
No. 2.	"	24 hrs.	No. 7.	"	4 days, 8 hrs.
No. 3.	"	2 days.	No. 8.	"	5 days, 1 hr.
No. 4.	"	2 days, 19 hrs.	No. 9.	"	7 days, 4 hrs.
No. 5.	"	2 days, 22 hrs.	No. 10.	"	8 days, 1 hr.

a series of pictures to illustrate in the same manner the progressive development of the rabbit. Numbers one to five of the figures upon the screen represent what is known as the germinal area, in the center

of which the actual embryo is gradually formed. In No. 1 merely the axis is indicated, in front of and alongside of which the parts of the embryo are to arise, as is suggested by Nos. 2, 3, 4, 5. These stages cover the seventh and eighth days. Nos. 6 to 14 figure actual embryos, No. 6 of nine and a half, No. 14 of fifteen days. No. 6 is singularly twisted into a spiral form, the reason for which is still undiscovered. No. 9 shows the condition at eleven days—notice the limbs, a leg in front and a leg behind, each only a small mound as yet upon the sur-

11

FIG. 36. A CHICK REMOVED FROM AN EGG, WHICH HAD BEEN INCUBATED 10 DAYS AND 2 HOURS. Magnified four diameters. After Keibel.

face of the body; the distinct eye, the protuberance caused by the heart. Nos. 11 and 12 show the embryonic shape at twelve and a half and at thirteen days—there has been a great increase of size with accompanying modifications of form. The next pair, Nos. 13 and 14, present us embryos of fourteen and fifteen days, respectively, and you see that the growth is very marked indeed, and the change of form obvious; the creature is now changing from the embryonic type into something resembling a rabbit. Other pictures could readily be added, but, though two weeks must still elapse before the animal will be ready to enter the world, it is not necessary for my present purpose to include this period in our survey. We need only contemplate, it seems to me, the series of drawings in Fig. 37 to realize that the early embryonic growth

of the rabbit, like the embryonic growth of the chick, proceeds with a speed which is never paralleled by the growth during later stages.

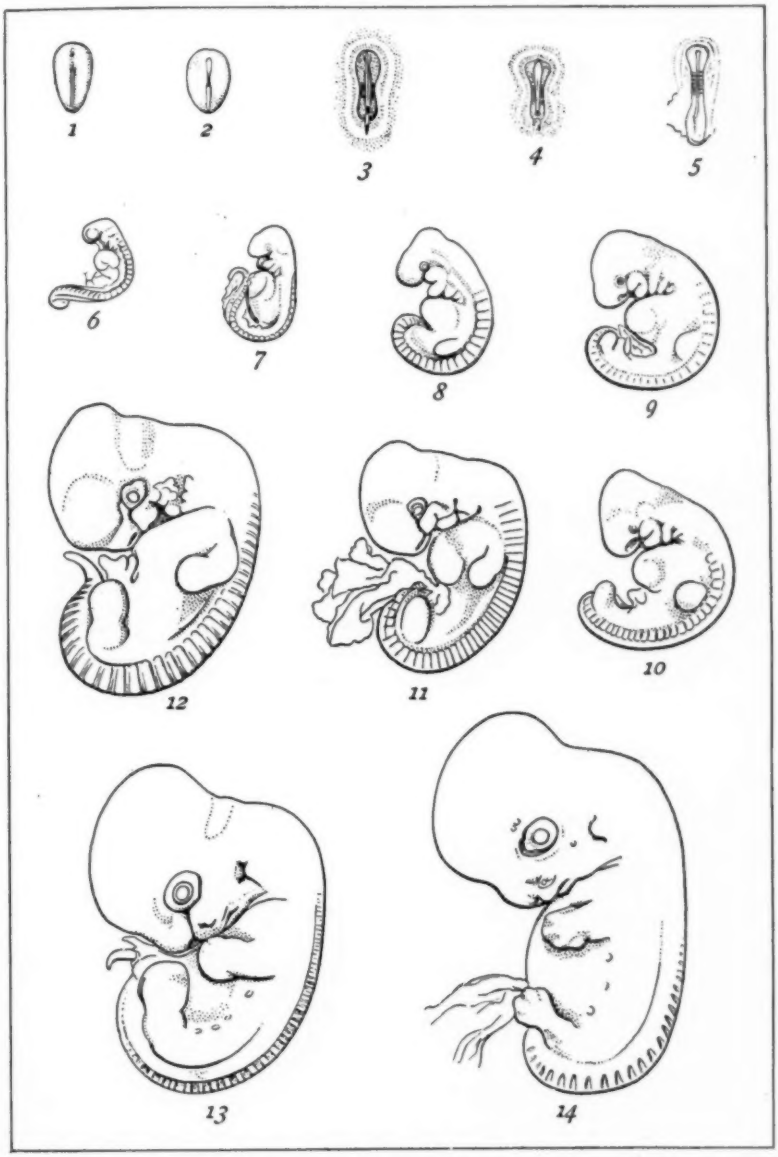


FIG. 37. FOURTEEN STAGES OF THE DEVELOPING RABBIT, after Minot's and Taylor's "Normal Plates." All the figures are magnified four diameters. Nos. 2 to 5 are irregular as to age, but show successive stages of development. The early development is extremely variable and the observations do not yet suffice to determine the average typical condition for each day under nine.

No. 1.	Embryo of	7½ days.	No. 8.	Embryo of	10½ days.
No. 2.	"	8¼ "	No. 9.	"	11 "
No. 3.	"	8¼ "	No. 10.	"	11½ "
No. 4.	"	8 "	No. 11.	"	12½ "
No. 5.	"	8½ "	No. 12.	"	13 "
No. 6.	"	9½ "	No. 13.	"	14 "
No. 7.	"	10 "	No. 14.	"	15 "

Now I had a considerable number of rabbit embryos preserved in alcohol, and though it was not very accurate to weigh them as alcoholic specimens, in order to determine their true weight, yet I resolved to do so as it was the best means at my disposal at the time. The result of that weighing was very interesting to me, because it showed that in the period of nine to fifteen days the rabbit had, on an average, added 704 per cent. to their weight daily; but in the period of from fifteen to twenty days, the addition is very much less than this, only 212 per cent. But these rabbits at ten days have already had a considerable period of development behind them, and as we have discovered that the younger the animal the more rapid its growth, we are safe, it seems to me—since we have learned that from the tenth to the fifteenth day there is a daily increase of over 700 per cent.—in assuming that in yet younger rabbits an increase of a thousand per cent. per day actually occurs. That is not so extraordinary an assumption, for bacteria are known to divide every half hour, and if the little bacterium divides and grows up to full size in half an hour, and then divides again, it means that within a half hour one bacterium has become two, and has increased, obviously, 100 per cent.; and if those two again divide as before, we should have four bacteria at the end of an hour—an increase of 400 per cent., and at the end of another half hour, of 800 per cent., and so on ever in geometrical progression. We learn, then, that bacteria may in a few hours add 1,000 per cent. to their original weight, and it is not by any means an exorbitant demand upon our credulity to accept the conclusion that in their early stages, rabbits and other mammals and birds are capable of growing at least 1,000 per cent. a day. If this be true, and it doubtless is true, we can adopt it as a convenient basis for comparison. As we learned from the rate curves, which were projected upon the screen earlier during the hour, the male rabbit gains in one day immediately after birth nearly eighteen per cent.—seventeen and four tenths per cent.—and the female rabbit gains nearly seventeen per cent. Now we can estimate the loss very simply by deducting this rate, which is the capacity of the animal to grow persisting at birth, from its original capacity, which we assume to have been 1,000 per cent. per day. And if we do that the result is obvious. Over 98 per cent. of the original growth power of the rabbit or of the chick has been lost at the time of birth or hatching, respectively, and the same thing is equally true of man. We start out at birth certainly with less than two per cent. of the original growth power with which we were endowed. Over 98 per cent. of the loss is accomplished before birth—less than two per cent. after birth. That, I think is a rather unexpected conclusion, certainly not one which, until I began to study the subject more carefully, I in the least expected; and even now when I have become more familiar with it, it still fills me with astonishment, it is so different from the conception of the process of development as we commonly hold it, from our conclusions based on our acquaintance

with the growth and progress of the individuals about us. We overlook the fact that the progress which each individual makes is the result of accumulation. It is as if money was put into the savings-bank; it grows and becomes larger, but the rate of interest does not alter. So too with us; we see there is an accumulation of this wealth of organization which gives us our mature power. But as that accumulation goes on, our body seems to become, as it were, tired. We may compare it to a man building a wall. He begins at first with great energy, full of vigor; the wall goes up rapidly; and as the labor continues fatigue comes into play. Moreover, the wall grows higher, and it takes more effort and time to carry the material up to the top of the wall, and to continue to raise its height, and so, as the wall grows higher and higher, it grows more slowly and ever more slowly, because the obstacles to be overcome have increased with the very height of the wall itself. So it seems with the increase of the organism; with the increase of our development, the obstacles to our growth increase. How that is I shall hope to explain to you a little more clearly in the next lecture.

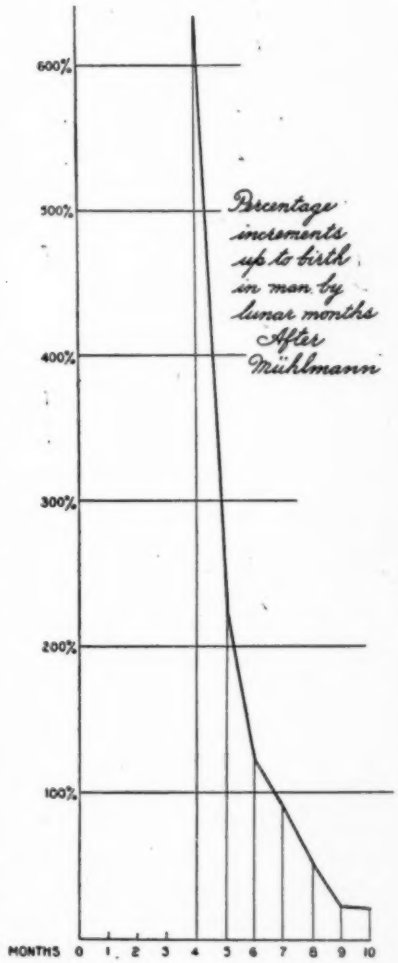


FIG. 38.

We have one more slide, which I would like to show you. It indicates the rate of growth in man before birth as far as it can be indicated without better knowledge. The time intervals in the diagram correspond to the so-called lunar months—the ten lunar months of prenatal life. Of our early development we know very little so far as statistics are concerned, but from the third month onward we have some records. It is found that from the third to the fourth month the increase is 600 per cent. Just contrast that with 200 per cent. added in one year after birth; 600 per cent. in one month against 200 per cent. in one year. From the fourth to the fifth month it is scarcely over 200 per cent. It then becomes only a little more than 100. In the seventh month, less than 100; and finally in the ninth and tenth months, it

becomes very small indeed, less than 20, so that during the prenatal life of man, as we have seen in the prenatal life of the rabbit and of the chick, the decline in the power of growth is going on steadily all the time.

I shall use the few remaining moments to report to you yet another bit of evidence of the originally enormous power of growth. It has been estimated that the germ of the mammal, with which the development commences, has a weight of 0.6 milligram; another estimate which I have found is of 0.3 milligram.[3] Perhaps I can give you some idea of what this value means by telling you that if the weight of the original germ of a mammal is assumed to be 0.6 milligram, we could, according to the laws of the United States, send 50,000 such germs by letter postage for two cents. It would take 50,000 germs to make the weight of one letter. That perhaps will give you some impression of the extreme minuteness of the primitive germ. In the human species at the end of even a single month it is no longer merely a germ, but a young human being, very immature, of course, in its development, but already very much larger. I doubt—even after all that I have said this evening about the startling figures of growth for the earlier stages,—I doubt if you are prepared for the fact that the growth of the germ up to the end of the first month represents an increase of over a million per cent. How much over a million per cent. we can not calculate accurately, because we do not know accurately the weight of the original germ, but an increase of a million per cent. is not above the true value. Contrast that with anything which occurs in the later periods. What a vast change has happened! What an immense loss has taken place! The rate of this loss is evidently diminishing. The loss occurs with great rapidity in the young—less rapidity the older we become. I attempted to convince you in the first and second lectures that that which we called the condition of old age, is merely the culmination of changes which have been going on from the first stage of the germ up to the adult, the old man or woman. All through the life these changes continue. The result is senility. But if, as the phenomena of growth indicate to us so clearly, it be true that the decline is most rapid at first, then we must expect from the study of the very young stages to find a more favorable occasion for analysis of the factors which bring about the loss in the power of growth and change as the final result of which we encounter the senile organism. Not from the study of the old, therefore, but from the study of the very young, of the young embryo, and of the germ, are we to expect insight into the complicated questions which we have begun to consider together. I shall hope in the next lecture to prove to you that the supposition which has guided my own observations is correct, and to be able to show you that we do actually, from the study of the developing embryo, glean some revelations of the cause of old age.

[3] These estimates refer to the placental mammals only.

A SCIENTIFIC COMEDY OF ERRORS

BY PROFESSOR T. D. A. COCKERELL AND PROFESSOR F. B. R. HELLEMS
UNIVERSITY OF COLORADO

THE scientific man of any period, if he will examine the work of his predecessors, may be comforted or discouraged, according to his point of view. It is in the highest degree encouraging to note the steady and rapid progress of science during the last two hundred years and more. It is flattering to the vanity of us moderns to realize that we stand on the very apex of the pyramid of knowledge which the human race has erected at the cost of so much toil, and can look down with indulgent contempt on the comparative ignorance of earlier generations. How stupid they were! How little they knew!—but we —well, there really never has been anything so superior. There is, however, an ancient story about a monkey which climbed a pole and for every three feet he climbed he slipped down two. Was the animal, after all, certainly a monkey? Is there no similarity between his progress and that of the human race? If the science of the past reads to us to-day like a comedy of errors, is it perfectly certain that our productions will not so appear to that hateful body of supercilious critics, our posterity? On second thought, there may be in the history of human learning as much cause for modesty as for exultation. As a tangible case in point we present a summary of the early history of the cochineal and allied dye-producing insects, and more particularly of a forgotten pamphlet by one Frederic Friedel, whereby he earned the degree of doctor of philosophy at the University of Leipzig, in 1701. For his time, Friedel was a man of unusual wisdom, filled with the true spirit of science, so much so that he was not afraid to tilt against the greatest of biological authorities then living, and, in so doing, came out with a flying pennant. Yet, in the light of modern knowledge, it appears that he corrected the blunders of Leeuwenhoek only to make somewhat lesser ones of his own; not, however, through lack of care or lack of sense, but from the unavoidable imperfection of his knowledge.

From very early times, it was customary to utilize the coloring matter obtainable from certain small round objects to be found on various species of oaks in the region of the Mediterranean. Dioscorides and other authors report their occurrence in Galatia, Armenia, Cicilia, Spain, Portugal and Sardinia: in later times they have been known in the south of France, Crete and Syria; while the north of Africa has furnished a less valuable kind. To Theophrastus they were known

Q. D. B. C. J.

Inclyto Philoſophorum Lipſienſium
Ordine conſentiente,

DISSERTATIONEM PHYSICAM
DE

COCHINILLA

H. L. Q. C.
Ad d. 1 Mart. Anno 1701.
Placido Eruditorum Examini publice ſubjiciet
PRÆSES
M. CHRISTOPH. FRIDERICUS
Richter/ Lipſienſis,
RESPONDENTE
FRIDERICO Friedel/ Scaudiza-Ciz. Miſn.
Med. Cult.

LIPSIÆ,
Excudebat CHRISTOPH. FLEISCHERUS.

as the κόκκος φοινικός, while in later times the name *Kermès,* from the Arabic, came into general use.

For many centuries the nature of the Kermes remained uncertain. To all appearances it was a berry, and the opinion that it was of purely vegetable origin prevailed. However, it appears that Quinqueran de Beaujeu, as early as 1551, published a book on the productions of Provence, entitled *De laudibus Gallo-Provinciæ,* in which he clearly indicated that the Kermes was an insect, and described its transformations. The supposed berries, says he, are the mothers, who presently have families of innumerable very minute worms. These latter locate upon the twigs at various points, increase in size, and at length look no longer like animals, but peas.

Planchon, to whom we are indebted for the reference to Quinqueran, goes on to remark that it is curious that after these observations had been published, many intelligent writers showed hopeless confusion upon the subject. In particular, it had been observed that from the Kermes sometimes issued small four-winged insects not unlike those coming from the oak-apples or galls. Hence it was concluded that the Kermes must be a sort of plant gall, wholly made up of

vegetable tissue, but nourishing an insect. We know now, of course, that the four-winged insects were merely parasites of the Kermes, which lived as minute maggots within its body, destroying it and finally issuing as adult flies.

With the discovery of Mexico, things took on a new turn. Francisco Hernandez and others reported that on the tuna, or prickly pear, of that country there grew a new sort of coccus, which was much to be preferred to the one found upon the oak, or to the scarlet grain found upon the roots of plants in Poland.

This new coccus, which came to be known as the cochinilla, or cochineal, was largely imported into Europe; and eventually the cacti were brought over, and grown in Algeria, Madeira, etc., so that the dye-material could be produced nearer the market. With the impetus thus given to the study of coccus—or, as we should now say, the Coccidæ—the question as to the true nature of the material pressed anew for settlement. According to the "Encyclopædia Britannica," the idea that the cochineal was the seed or fruit of a plant was prevalent as late as 1725, but Martin Lister, in 1672, indicated its relation to the insects. In 1703, it is stated, Leeuwenhoek discovered its true nature by the aid of the microscope, "but not unnaturally supposed it to be allied to the ladybird."

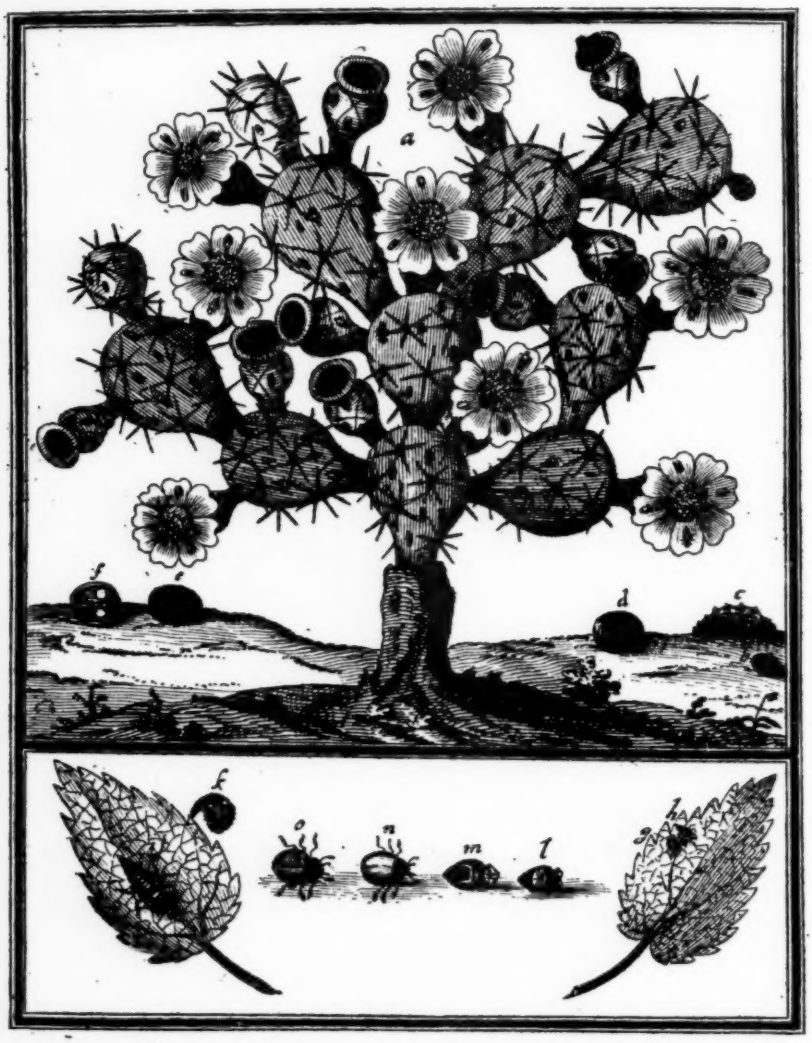
This statement of the case, however, is not quite exact. We have before us a little pamphlet published as early as March, 1701, the precise date, according to a penciled figure, being the fourteenth of that month. This work is a thesis for the degree of doctor of philosophy, presented to the University of Leipzig by Frederic Friedel, and is entitled *Dissertatio Physica de Cochinilla.* In it, the whole question of the nature of the cochineal is fully discussed, with copious references to previous authors and many original observations.

The work consists of six chapters; the first on the name of the cochineal; the second on its habitat and the plants infested, with some interesting information on the different kinds of cacti; the third on various opinions concerning the nature of the cochineal; the fourth giving the details of the author's views as to its nature; the fifth on its culture and the methods of collecting it; and the last on its different varieties and its uses. The whole treatise is, of course, in Latin, but we give a free translation of the parts with which we are particularly concerned, abbreviating here and there.

After giving a general summary of the hitherto recorded observations and opinions, Dr. Friedel proceeds:

> Therefore, this insect is a Coleopteron [beetle], so to speak sheath-winged, or in a word, belonging to the family of lesser scarabs, which we recognize by the almost round body, flat below and convex above, not less than by a reddish and golden color, sprinkled with some black spots.

He then proceeds to set forth the names for the ladybird in dif-



ferent languages, bringing out the fact that these creatures are dedicated to Our Lady, the Virgin Mary, or in other cases to God, for reasons not explained. In France they are called God's horses, Chevaux de Dieu, in England ladybirds or cowladies, and so forth.

To these familiar ladybirds,

> such exact resemblance is borne by the little animals which produce the cochineal, that one egg could scarcely be more like another, if only you except the size, in which the American beetle is observed to surpass ours, and the color, which is not vividly red or scarlet or yellow in the foreign species, but dull and brownish, with the spots red, the latter larger than those on our beetles.

The modern entomologist begins to wonder what all this has to do with

the cochineal, which is by no means a beetle, though truly an insect, but the author proceeds:

Moreover, tnese statements that I have made about the form and appearance of this beetle, that they may not be accounted the mere offspring of my brain, can all be easily verified by actual examination; for dry specimens, complete, generally, however, with the head and feet torn off, are found mixed with the cochineal; or at least, as happens more commonly, elytra are brought out along with the cochineal grains. I myself have found several points concerning these little animals, complete or intact for the most part, which exactly agreed with those just described, so that all occasion for doubting the truthfulness of the facts has been removed.

With this description, aided by an excellent figure given in the one plate which ornaments the pamphlet, we are able without difficulty to explain the mystery. The American beetle is the *Chilocorus cacti,* a genuine ladybird, which does indeed live upon the tuna among the cochineal insects, *feeding upon them.* When the latter are gathered, the beetles are often carried with them, and Friedel, examining the dried grains, naturally found the specimens he describes. In 1701 not much was known about the classification of insects, and it never occurred to him that a creature like the cochineal, which we now know to have a sucking mouth, could not be related to a beetle.

Yet, aware that scoffers exist, the author is constrained to proceed:

Howbeit, if this evidence of mine should not find full credence, look you! here is Paulus Ammannius, who in his handbook to Materia Medica reports that he also found such a little animal intact; and if perhaps he is not sufficient authority either, take Leeuwenhoek and Tyson, of whom the former depicts little insects of this type, found by him likewise, and the latter even gives an engraving on copper of a cochineal scarab, and when you have compared the figures, you will agree that it is as closely similar as possible to mine. In the appended plate, I offer one of those that I happened to find, along with our nettle beetle [that is, the European ladybird, *Adalia bipunctata*], because the difference, as well as the resemblance between them, will thus better meet the eye. I willingly omit the references to other authors, such as Blanchard (Schauplatz der Raupen) and Dale (Pharmacology), for the two just mentioned, Leeuwenhoek and Tyson, are for me equivalent to all.

Friedel then proceeds to combat an opinion, which he attributes to Leeuwenhoek and an anonymous Spaniard mentioned in the English Transactions (of the Royal Society) No. 193, to the effect that the cochineal is a portion of the adult American ladybird—the *Chilocorus cacti.*

For it is disproved oy ocular examination, that the lower belly of this beetle, if it shall have been stripped of its legs and head, and finally of its elytra and wings, as indicated by Leeuwenhoek, exactly resembles the cochineal. Rather, the form of these hinder parts of the insect differs as much as possible from the little body of the cochineal; seeing that in the first place, in size it generally very greatly surpasses the lower belly of the beetle, as I have found in more

than one case when I have removed from the intact beetles found among the cochineal the parts just mentioned; and in the second place, I have noticed this marked discrepancy, the abdomen of the beetle is never marked by more than six or at the most seven distinct rings, but the number of these in every grain of cochineal generally runs as high as 12, as can be seen with the naked eye, or more distinctly with the aid of the microscope, especially if the insect has been softened in water. Furthermore, a third difference will be noticed at the same time—you will certainly observe the anterior half of the cochineal to be furnished with some little swellings, beneath which lurk the feet of the insect which are going to appear, and which the engraver has tried to show in the cut. On the other hand, that the hinder parts of the beetles are always entirely devoid of these swellings an examination places beyond limits of doubt. Add to all these the fourth circumstance that the abdomen of the beetle does not produce any purple color, and for that reason could little serve the purpose for which this ware is imported from such distant shores. Although I subjected certain of these trunks of the lower belly to different treatments, I never was able to see even a tiny point of the desired color in them, while conversely, any tiny cochineal will discharge the color in sufficient abundance and at once. And finally, I have never been able to find in the belly of the beetle a single little grain or egg, although I sought most zealously; whereas such are found in great abundance in any cochineal which is broken up after having been sufficiently macerated.

What an excellent argument! It is proven beyond doubt that the cochineal is no part of the ladybird, notwithstanding the assertions of the most eminent authority then living. We have no fault to find with particulars given, except that the little prominences on the cochineal, where the legs were hereafter expected to appear, were in reality the bases of the minute legs of that insect.

Returning now to the constructive argument, the author gives his conclusion that the cochineal must be derived from the aforesaid beetles, and yet is not any part of them. The simple explanation is that the cochineal, when mature, transforms into a beetle, and in doing so utterly loses the power of staining, and hence is no longer to be termed a cochineal. Now this loss of color at maturity is paralleled by other phenomena already recorded. In the case of the dye-coccus of the oak, the *Kermes,* so long as the little berries are full of little worms or animals, they are rich in the colored juice. After a while, when the little worms [the larvæ of the *Kermes,* in reality] are called by the heat of the sun from their sacs [that is, the bodies of their mothers] they can be destroyed by the pressure of the hand, and forced into a mass which is appropriately termed vermillion. Otherwise, before the exclusion of the worms, the dried berries will equally preserve the desired color. It is just the same in the *coccus polonicus* [*Margarodes polonicus* of modern entomologists], which is said to cling to the roots of several herbs. These little bodies at a stated time turn into little winged insects, as is stated by several authors, including Martin Bernhard in his description of the Royal Garden of Varsovie. As soon as

these insects [probably males of the *Margarodes*] fly away, they are manifestly deprived of all color, and not only this, but the cortex which is left retains nothing of the precious coloration.

So, says Friedel, since in all these different sorts of coccus the red color disappears in the last stage, when the creature is transformed into a fly or some other little animal, it is easy to understand why the beetles produced from the cochineal show no red pigment. The point is important, because it is necessary that the cochineal should be collected in time, before its last transformation, and while it is still swollen with the juice.

The analogy is here not very convincing, since the *Kermes* does not turn into a single insect, but produces a multitude of "worms," as Friedel clearly states. It seemed sufficient to him, however, and he never got a glimpse of the true fact that the cochineal insects do indeed turn into the beetles, in the same manner that the lamb may be said, under suitable circumstances, to be transformed into the lion.

Assuming that the cochineal was the pupa of the beetle, it remained to fortify this conclusion by still other arguments. In the first place, Herrera and Laetus had given some slight account of the development of the cochineal, from actual observation. From this it might be gathered that there was at first a minute or mite-like insect, which developed into the cochineal-grain. This accords very well, so far as it goes, with what was to be expected according to the theory. "That grain is covered on the outside by a certain thin tunic, which contains shut up within it the little animal, which is soon to be transformed into a beetle"—this is, however, an inference of Friedel's, not of Herrera's.

"But," says Friedel, "for a more beautiful illustration of my hypothesis, I thought I might describe the transformation of the European ladybird, which is certainly sufficiently allied to the American to permit accurate deductions to be drawn from it." So he went first to the book on insects by John Goedart "that very illustrious painter of Middleton," a work which several years back Martin Lister had published in a new and revised edition. In this work, p. 274, it appeared that first from little blackish eggs deposited in a sort of circle on the leaves of the *Ribes* [currant or gooseberry], there sprang, "from the nurturing of the summer air," little animals, which immediately after hatching could scarcely move, until after an interval of several days they learned to creep a little, and finally to run about freely. These insects were subsequently observed to shed their skins, like serpents, as they increased in size, and this was done four distinct times, and last they obtained the final red skin, variegated with black spots. To these statements the author added that as often as these beetles stripped themselves of their skins, they fixed their feet firmly in the place they occupied, and crept out, leaving the empty skin in its

natural form, so that at the first glance you would swear the little animal was still standing there.

"Now," says Friedel, "As I read this, it can scarcely be told how saddened I was, for the hope I had previously conceived was falling into ruin." The account of Gœdart did not really seem to confirm the hypothesis about the cochineal, for there was no description of any stage that really corresponded to the grain. Friedel was about to change his opinion in toto, when he "had another seasonable suggestion from the most excellent Dr. Lang, to whose most faithful training I owe almost everything in the course of my medical studies." For as Dr. Lang was the first to suggest to Friedel the theory about the nature of the cochineal which formed the subject of this thesis, so he now came to the rescue with facts and experiments concerning the German ladybird "depicted as in life with an elegant brush in colors, and most accurately noted from day to day," all of which, in the year just passed, Friedel was permitted to observe and confirm with his own eyes.

Sure enough, in the month of June, on the upturned leaf of the greater nettle, are seen very tiny egglets of a saffron color, adhering firmly. As may be seen in our illustration, letter *g*, from these, a little later, are spontaneously hatched blackish oblong little worms, below the size of a flea, but equipped with six feet on the anterior part of the little body, see letter *h*. These little insects are sluggish for some time after their birth, and scarcely move from their place; until, after the lapse of several days, they acquire the necessary strength, and running hither and thither, gather food, so far as we can see, from dew. [They feed on aphides, but Friedel neither observed this, nor considered the fact that mere dew was rather unsustaining!] After about three or four weeks have elapsed, they reach a size such as is indicated under letter *i*. At this time, they are elegantly ornamented on the sides with several yellowish spots, and their color, dark before, is changed to an ashen hue, especially along the middle of the back. Now this fleet-footed worm prepares itself for a metamorphosis, wandering more tardily at first, soon hardly at all; and then, affixing itself by its tail to a leaf, is wrinkled up as shown under letter *k*. By degrees the covering drops off to the rear, and it passes into the pupula or nymph, of which the anterior and posterior aspects are shown under letters *l* and *m*. The insect, even in this state, still lives, as may be learned from its movement when touched. It remains thus until the tenth and not rarely the twelfth day, when the covering is broken, and there comes forth, the skin being left motionless, a beetle, which at first is rather weak, and whitish, but changing in a few hours to yellow or red, the black spots coming into view on the elytra.

This is really an excellent account of the ladybird, excepting only the error as to its food, and from these observations Friedel felt encouraged to believe that he had put the finishing touches on his theory of the cochineal; for was not the ladybird pupa just like it? "But," says he, "if perchance this should still seem doubtful, here is a further observation to confirm it. When a friend, addicted to trade, gave me at one time a large enough heap of cochineal to examine, I

found mixed with it several worms, not yet altogether changed into pupæ, of a color which from ashen was becoming purple, and which when immersed for a while in water, assumed the form seen in the engraving under the letter *C*. Hence there came to me the suspicion that under this form appeared the worm of the cochineal before giving itself to rest; for that it certainly belongs to this family, I am persuaded by the purple color which it discharges into the water in which it is immersed, just like the cochineal itself. For when all the eggs of these insects are not hatched in one precise day it at least becomes probable that neither are all these worms in one moment transformed into pupæ, or the beetles simultaneously creep forth from these. So, without doubt, when the harvest of pupæ is at hand, several of these worms, which have not yet reached the pupa state, and also several adult beetles, are shaken off at the same time from the tuna. Consequently, we usually find them all mixed, in more or less abundance, with the best cochineal." The worms thus found may be the true larvæ of the ladybeetle, or in other cases, the larvæ of certain two-winged flies of the family Syrphidæ, which also prey upon the cochineal. The presence of the flies is especially indicated by another observation of Friedel's—that he found even a few cup-shaped objects, in which were occasionally seen some small grains of cochineal. Here, he thought, were actually the skins left empty after the exit of the beetles; but on further reflection he abandoned the idea, as they really were not large enough to hold the beetle. The grains found in them were very minute, and were doubtless only cochineal larvæ which had wandered in by accident; and finally, some of these cups still contained, not a beetle, but a single fly. These were, we may now rest assured, the puparia of a predatory Dipterous insect, either a Syrphid or a species of *Leucopis*.

By the time of Linnæus, some fifty years later, it was clearly known that the cochineal had nothing to do with the beetles, but belonged to the Hemiptera. Even then, however, it seemed fated to be a source of error and misunderstanding. When Linnæus was preparing his great "Systema Naturæ," a friend of his, Daniel Rolander, resident in the West Indies, sent him what he supposed to be unusually fine specimens of the cochineal alive on a piece of cactus. Linnæus naturally used these in making his description of the *Coccus casti*, and until 1899 nobody seems to have suspected that they were not the real cochineal. However, Rolander sent some at the same time to DeGeer, who figured them, and from the account he gives, and indeed also from that of Linnæus, it is evident that the *Coccus cacti* L. is no cochineal, but a species of a quite different subfamily, which, curiously, has never been found by any entomologist since it was discovered by Rolander.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DELAND

PITTSBURGH, PA.

XIV. Telephonic and Financial Conditions, 1880–1883.

FOLLOWING are the Bell statistics for the four years, 1880–1883: On March 1, 1880, there were 138 Bell telephone exchanges, in operation or about to open, while a year later the number had increased to 408, a net gain of 270 exchanges, or of nearly 200 per cent. Though only three years had elapsed since the first of these pioneer exchanges was opened, on March 1, 1881, 66 exchanges were interconnected by toll lines, Boston had toll communications to seventy-five cities and towns, the total number of places for which licenses to build exchanges had been granted was 1,523, and thirty-two contracts had been given to build connecting toll lines. But, these 408 exchanges supplied telephone service to only 47,880 subscribers located in 463 cities, towns and villages, or an average of only 117 subscribers to each exchange.

At the close of the year 1881, the number of Bell exchanges had increased to 592, with a total of 70,525 subscribers, located in 1,593 cities, towns and villages, while the average number of subscribers per exchange had increased from 117 to 120.

On December 31, 1882, there were 1,070 Bell exchanges in operation, a net gain of 478 for the year, or of 81 per cent. This growth represented an average increase of two new exchanges for nearly every working day in the year. Yet the total number of subscribers was only 97,728, or an average allotment to each exchange of only 91, that is, 29 less subscribers than the average of the previous year. The handiwork of the speculative builder of small exchanges, grasping for quick profits, is here indelibly imprinted on the records. In the large exchanges the high flat rate limited the growth to the wealthy in the resident districts and to the larger business houses and professional offices where telephonic communication was an absolute necessity. This seems a reasonable conclusion to draw from a growth of only 38 per cent. in subscribers and of 81 per cent. in exchanges.

And the record for 1883 is of the same delusive character. On December 31, there were 1,325 Bell exchanges in operation in 46 states and territories, supplying service to 123,625 subscribers, and giving employment to 4,762 persons. In other words, there was an average of nearly four employees to each exchange, though the aver-

age number of subscribers connected was only 93. And as there were many exchanges having more than 300 subscribers, it is obvious that many others had less than 30, and thus were being operated and maintained at a continuing loss.

What were the financial conditions of the country during these four years, 1880–1883? What was the character of the sentiment prevailing among investors that enabled such anomalous conditions to continue?

The year 1880, notwithstanding that a presidential election occurred, proved to be an admirable period for the promotion of industrial as well as speculative enterprises, and telephone projects of every character appeared to meet a hearty welcome at the hands of the investing public. To the older licensees, enriched by the wisdom gained in a whole year's experience, it soon became evident that many of the new exchanges were being built and operated only for speculative purposes by local promoters, in anticipation of profitable consolidations, rather than as a permanent investment for local capital. For the question of equitable rates yielding a fair return on a legitimate investment, or the unpleasant results in lowering the character of the service by giving unlimited calls at an unprofitable rate, thus loading the lines with gossip and frivolous conversation, to the detriment of rapid, legitimate service, did not concern the speculator. Where the older licensees endeavored to warn local investors against accepting the speculator's statements without substantial proof, the latter felt justified in agitating a public denunciation of what he termed the extortionate rates of the older licensees. The natural result was that the speculative exchanges had a big list of subscribers at unprofitable rates, until consolidation brought a new management that proposed to take care of the shareholders first and then give the best service possible to the subscribers. This meant an increase in rates to an amount that would insure a fair return on the investment; and then fully one half the subscribers who had been reaping the advantage of unprofitable rates promptly displayed their gratitude by giving up the service rather than pay the increased price.

On January 21, 1881, many of the telephone companies in the east suffered from the most destructive sleet storm that had visited that section in a long period. So great was the weight of the sleet frozen on the wires attached to roof-fixtures that in numerous cases the roofs were wrecked and walls were damaged. Miles of the pole lines went down, and in the main thoroughfares of the larger cities telephone wires were inseparably entangled with telegraph and electric light circuits. By reason of modern methods of construction, a disaster of such a character could not now occur, though greater losses have occurred in several sleet storms. But this was the first serious wreck

of the kind that the new telephone industry had had to face, and its disastrous outcome was exceedingly discouraging. The immediate loss to the New York company was nearly $100,000, while the indirect loss in delaying extensions and improvements and in diverting investment from the treasuries of the injured companies was very large.

The only remarkable change in financial circles occurring in 1881 was the flurry in the stock market that followed the assassination of President Garfield on July 2, 1881. To the far-sighted financier that "agitation approaching a panic" may have indicated the beginning of the general depression that gradually overspread the country and proved most severe in 1885.

On July 14, 1881, the New York *Tribune* editorially asserted that

> the agitation that caused the flurry was utterly without foundation and that the proportion of business done upon a cash basis is larger than ever, and the proportion of business done without borrowing, on the capital of the firms engaged, is larger than ever. . . . Nor has there ever been a time when the earnings of the people were on the whole as large as they are now. Wages are good, while prices are relatively low.

But from the telephone speculator's point of view, the ill effect of that July flurry was more than offset, so far as the investing public was concerned, by the admirably wise and now famous telephone decision rendered by Judge Lowell on June 27, 1881, in the suit begun on June 22, 1880, in the Eaton-Spencer case. In part that opinion read as follows:

> If the Bell patent were for a mere arrangement, or combination of old devices, to produce a somewhat better result in a known art, then, no doubt, a person who substituted a new element not known at the date of the patent might escape the charge of infringement. But Bell discovered a new art—that of transmitting speech by electricity—and has a right to hold the broadest claim for it which can be permitted in any case; not to the abstract right of sending sounds by telegraph, without any regard to means, but to all means and processes which he has both invented and claimed. . . . The claim is not so broad as the invention. . . . An apparatus made by Reis, of Germany, in 1860, and described in several publications before 1876, is relied on to limit the scope of Bell's invention. Reis appears to have been a man of learning and ingenuity. He used a membrane and electrodes for transmitting sounds, and his apparatus was well known to curious inquirers. The regret of all its admirers was, that articulate speech could not be sent and received by it. . . . A century of Reis would never have produced a speaking telephone by mere improvement in construction.

President Arthur proved a worthy successor to the lamented Garfield, and his strong and conservative policy appeared to win the confidence of the people, many of whom had been led to expect a more radical and less safe administration. Thus the year 1882 opened

auspiciously for all speculative interests. But in February came the notorious break in Richmond and Danville, from 219 to 130, that flurried the stock market and increased the general uneasiness concerning all investments. Nevertheless, the total volume of business transacted throughout the country during the year was very large, no less than $350,000,000 being expended in new railroad construction.

The general financial and commercial conditions that prevailed during 1883 may be summed up as follows: There were 9,184 failures with aggregate liabilities of $172,874,000, as against 4,735 failures in 1880 with aggregate liabilities of only $65,752,000. Not only was there a large decrease in the total volume of trade, making retrenchment in nearly every line of industry an imperative necessity, but a general distrust of the integrity of all stocks and all bonds prevailed, with a consequent enormous decline in the market values of many securities, including even those of the new telephone consolidations. An eminent financial writer in referring to the speculative fever that had raged during the previous two years, 1881–1882, declared that:

> **Our whole people became wild upon the subject of railroad construction, believing that two or three dollars could easily be made for every dollar put up, either by the success of their ventures or by the sale of their securities. In this delusion the capitalist and the adventurer shared alike.**

Nevertheless, notwithstanding these discouraging conditions, or the gloomy outlook for the coming year, or the nine thousand failures in other lines of business, or the low market value of the stock of certain large licensee companies organized to absorb the handiwork of the speculator as portrayed in numerous small and unprofitable exchanges, the art of establishing new telephone exchanges, especially in small towns and villages, progressed even more actively in 1883 than ever before. So many investors believed that it was only necessary to establish any kind of an exchange in any kind of a village, no matter how small or how unprofitable the rates might prove, to secure profits of three for one, that the editor of an electrical journal wrote: "No fable concerning the telephone is too gross to receive credence; no prediction of its future can be wild enough to provoke a smile." And the daily papers fed this delusion by constantly referring to millions of dollars alleged to have been made in the telephone business, although the parent company had paid no cash dividends prior to January, 1881, all of which statements many readers accepted as applying solely to exchanges established in small villages, just as three years earlier many investors believed that large profits would be derived from building small branch railroads. And had it not been for the many investments made by farmers in railroad securities, in the aggregate amounting to several millions of dollars, from which no return was secured in many cases, it is quite probable that the farming community

would have developed a rural system of telephone service contemporaneously with its early growth in towns and villages.

Again, the infringing telephone companies, and they were numerous, while their promoters were strong in political and financial influence in the '80's, circulated the most absurd statements concerning the millions that had been made in the consolidating of Bell operating companies, and the manipulation of telephone stocks. One statement read: "It is within limits to say that the entire property, rights and franchises of the Bell company and its licensees could be duplicated for one twenty-fifth of the stock capital invested." Yet it is interesting to note that during the three years, 1881–1883, in New York state alone, one hundred and twenty-five infringing telephone companies were organized and capitalized at an aggregate of two hundred and twenty-five millions of dollars, a capitalization authorized by one state only, and three times greater than the combined capital stock of all the Bell companies in all the states of the union, including that of the parent company.

Very fortunately for the investing public, few of these infringing companies ever got fairly under way, even when the highest officials in state and nation appeared to do all in their power to aid in filching rewards honestly won and meritoriously bestowed. Moreover, it has been stated that many of these infringing claims were offered to the parent Bell company for small sums or large sums, depending upon how gloomy or how roseate the outlook was. A comical phase of these infringing competitive schemes was the certainty with which statements would appear in printed circulars, that the telephone was first exhibited to the public at the Centennial Exposition in 1876, and the first telephone line was constructed in Boston in 1877. The fact that they thus admitted that Alexander Graham Bell's telephone was the first telephone did not appeal even to their sense of humor.

Even the announcement on January 24, 1883, of Judge Gray's decision on final hearing in the Dolbear case, and of Judge Lowell's decision the following August, did not appear to discourage investment in the securities of infringing companies, while both decisions served to stimulate the building of small exchanges by speculative promoters and the rapid consolidation of these non-paying properties into overcapitalized organizations.

Judge Gray's opinion in part was:

> The opinion in Spencer's case clearly points out that "Bell discovered a new art—that of transmitting speech by electricity—and has the right to hold the broadest claim for it which can be permitted in any case." . . . The evidence in this case clearly shows that Bell discovered that articulate sounds could be transmitted by undulatory vibrations of electricity, and invented the art or process of transmitting such sounds by means of such vibrations. If that art or process is (as the witnesses called by the defendant say it is) the only way

by which speech can be transmitted by electricity, that fact does not lessen the merit of his invention, or the protection which the law will give to it. . . . Whatever name may be given to the property, or the manifestation, of the electricity in the defendant's receiver, the facts remain that they avail themselves of Bell's discovery that undulatory vibrations of electricity can intelligibly and accurately transmit articulate speech, as well as of the process which Bell invented, and by which he reduced his discovery to practical use; that they also copy the mode and apparatus by which he creates and transmits the undulatory electrical vibrations, corresponding to those of the air.

On August 25, 1883, the opinion of Judge Lowell on final hearing was delivered in part as follows:

I decided in *American Bell Telephone Co. v. Spencer, 8 Fed. Rep. 509*, that Reis had not described a telephone which anticipated Bell's invention. The same point has since been decided in the same way in England. *United Telephone Co. v. Harrison, 21 Ch. D. 720.* It is admitted in the present case that the Reis instrument, if used as he intended to use it, can never serve as a speaking telephone, because the current of electricity is constantly broken; and it is essential for the transmission of speech that the current should not be broken. The defendant (Dolbear) now testifies that the Reis instrument can be made to transmit speech, under some circumstances, if operated in the way which Bell has shown to be necessary. In 1877, he several times expressed the opinion that Bell made the invention, and that Reis did not make it. The experiment made in the presence of counsel, which was intended to prove the correctness of the defendant's present opinion, was an utter failure. . . . At the former hearing in this case before Mr. Justice Gray and me, we decided that the defendant (Dolbear), whatever the merits of his telephone may be, employs in it a part, at least, of Bell's process. No additional evidence has been given at the final hearing, unless a further explanation of that already given may be called additional; and I remain of the opinion expressed by the presiding justice at that time.

Telephone men were not alone in their realization that self-preservation lay in concentration. For financiers were beginning to perceive the wisdom in the original plan of one great company, to also realize how dependent the future growth and development of the industry was on a centralized policy, and to foresee that the product of unity in purpose, in method, in management, would be serviceable to users and profitable to investors. It was already evident that telephone service had come to stay, that it was an important aid in the transaction of business in every line of industry, and that it was certain to have a revolutionizing effect on many phases of industrial, commercial, professional and social life.

In its annual report for the fiscal year ending February 28, 1883, the parent Bell company said:

From the local companies throughout the country the reports are encouraging. Most of them are now earning and paying dividends, and extending their business with energy. An important feature has been the consolidation of local telephone interests into large companies, covering many counties, and even in several instances the whole or the greater part of entire states. This policy has

been assented to so far as its adoption seemed in the interest of convenient and economical management, but it should not be encouraged to an extent that would leave these companies entirely in the ownership of persons who are not residents in the territory where the business is carried on. It has always been our policy to keep local capital and influence interested in the business as far as possible, and to this course may probably be attributed a good part of the success which has attended the development of the business.

A year later the parent company reiterated the foregoing conclusions concerning care in consolidating companies and added:

In spite of the prevailing opinion that the development of the telephone substantially under one control is against public interest, we believe that an intelligent examination of this question would demonstrate that this is not true and that in no other way could the desired results be obtained and the difficulties be surmounted so rapidly and so well as by the present one.

Like the previous year, 1883 was a year of mergers; and when this two-year period closed, the number of Bell companies had been reduced, through absorption or consolidation, from several hundred to less than one hundred, and the parent company was gradually getting into a position where it could strongly influence the policy that should prevail.

In some states practically all the exchanges were absorbed by one strong company; in other states three or four companies aided in bringing about the consolidation, and then divided the territory. For instance, in the summer of 1882 the daily papers told how:

New York and Philadelphia capitalists are visiting various sections of Pennsylvania with a view to consolidate all local telephone companies between New York and Pittsburgh into one general organization, with main offices in New York, Philadelphia and Pittsburgh.

While the promoters failed in consummating so big an undertaking, their efforts paved the way for consolidations more limited in scope. In Massachusetts a combination known as the Lowell syndicate was quite successful in consolidating many exchanges, some of which will be more fully referred to in a following chapter.

Referring to the numerous consolidations of small local licensee companies into new organizations chartered to work on broader plans, the parent Bell company in its annual report for 1883 stated that:

the tendency towards consolidation of telephone companies noticed in our last report has continued and is for the most part in the interest of economical and convenient handling of the business. . . . As methods are devised for making the telephone commercially useful over long lines, the advantages of this centralization of management will be still more apparent, as well as the importance to the public of having the business done in large territories under one responsible head, with far-reaching connections throughout the whole country. To make this service of the highest value to the people will be complicated enough under one control. Were it in the hands of many competing companies, the confusion resulting would be very serious, as the value of the telephone will be largely measured by its capacity to give prompt connection with all parts of the country.

The parent company also held that the securities issued by its operating companies ought to represent legitimate values, not speculative or estimated values based on what the plant might earn in the future; that the intrinsic value of the telephone securities should be made clearly apparent to investors, and that the established integrity of the investment should be maintained by providing ample sinking-funds and reserves to cover every contingency. Its expressed policy was:

> to encourage payment of dividends by local companies with a view to getting local influence and capital interested in telephones, but it never encouraged the payment of dividends except when earned.

Such conservative methods were not in accord with the sentiments of speculators who preferred to experiment with the credulity of thoughtless investors, so long as such experiments yielded rich profits. The people believed the newspaper stories about the fabulous profits small telephone exchanges were deriving from limited investments. Then why destroy such honest beliefs by presenting cold facts? Consolidation of exchanges was a good thing; it meant large profits for the promoters.

When these local exchanges were transferred to the management of the new organization, it was quickly perceived that many subscribers were receiving service at rates involving constant loss to the company, as already stated. An increase in rates naturally followed, which, in turn, resulted in some of these low-rate subscribers discontinuing the use of the service. Sometimes from 25 to 50 per cent. of the subscribers to these consolidated exchanges would drop out, and the loss in the income anticipated from these subscribers upset many plans. For most of these new organizations, in expectation of being able to readily dispose of the new securities, had proceeded to reconstruct the old plants absorbed with a view to giving a higher class of service and of promptly and properly handling a large increase in the number of subscribers. To meet the indebtedness thus incurred it was necessary either to sell shares of stock at a price considerably lower than the authorized price, or else to settle the indebtedness with the funds set aside for dividend payments, and in lieu of cash payments to shareholders to issue stock dividends. Again, this inability to raise the funds necessary to make needed extensions and improvements and to keep pace with the growing demands of the public, meant that for an indefinite period the gross earnings must provide for all construction and reconstruction, as well as for the operating and maintenance charges. In other words, in 1883–1886, until improved financial conditions permitted the sale of telephone securities at reasonable prices, growth and progress were necessarily limited within narrow lines that yielded sure returns to the holders of stock certificates.

THE HEALTH OF AMERICAN GIRLS

By NELLIE COMINS WHITAKER,

SALEM, MASS.

IN a paper, 'Alumna's Children,' published in this magazine in May, 1904, the wish was expressed that some one might determine how far 'the way in which our girls go to school' governs their health in later life. This article is an attempt to consider that question. To any one familiar with all that has been written on the health of American women the subject must seem exhausted in one sense at least. As one reads the different monographs giving the cause of woman's physical weakness, each writer dwelling upon some one condition which is of itself entirely sufficient in his opinion to overthrow her health, one can but think of the man who committed five murders and was condemned to be put to death five times. Yet perhaps there is a word more to be said. A large proportion of the papers have discussed college students or adult women and almost every serious consideration of the health of the schoolgirl has been by a physician and necessarily from his point of view. A girl is more fully and more normally known to her mother and her teacher than to her doctor; they observe all the influences of her life as he can seldom do. For some reasons a wise mother would seem to be the one best fitted to speak on this matter; she should know more intimately than any one else the nature of her daughter. But the mother is limited to the conditions that have operated in her own family. The daughter's teacher learns the personality of the individual girl with a thoroughness second only to that of the mother and she knows just as intimately scores of other girls who have grown up under vastly different conditions, so that she is able to draw general conclusions as the mother of one or two can not do. I have not come upon any full discussion of the health of our girls from the teacher's point of view; it is this that I shall try to present.

The delicacy of our American women, noted abroad and admitted at home, is coming to be a tremendously vital question. The condition apparently is peculiar to no class and it appears in the second generation of other nationalities immigrating here. Lack of fecundity is only one of its indications. Does it not seem to you that most of the women whom you know confess that they are 'not very strong'? Nervous exhaustion and what the newspaper advertisements call 'womanly weaknesses' are the most common ailments, but there seems to be in women far more often than in men a lack of general vitality, an inability to resist disease.

This state of affairs is generally admitted, but there is no evidence that it was nature's original plan. On the contrary, there is reason to believe that the woman was meant to be quite as strong as the man; nature has ordained the hardest tasks for her, and has given her a wonderful equipment for them. Among primitive races the woman is fully the equal of the man in strength, his superior in endurance. Superior in endurance in certain respects she remains even under modern conditions, as dentists and surgeons bear testimony. But where has gone the vigor that she requires to meet the demands that life makes of her? Is it the schools and the teachers that are responsible for its loss?

I was moved anew to thought on the subject by seeing last June the Ivy-day procession of a woman's college and the next week the graduating exercises of a large high school. The college girls looked notably robust, sunburned as to cheeks and arms and hair, but attractive for their evident health. They seeemed far above the average American women in their physical vigor and did not lead one to believe that a college education makes invalids. The girls in the high-school class —the man beside me, himself the father of one of them, expressed their appearance adequately though bluntly when he said, "Those girls are a puny-looking lot." The characterization was true of that class; is it true of the average high-school girl? Consider the question for yourself as you see in June the graduates of your local high school. And those before you are the fittest who have survived; they are very few in number compared with those who have dropped by the way.

Ten years ago I read an unforgettable paper written by a high-school senior. She was a brilliant student who, maintaining the highest rank in her class, had done the preparation for Radcliffe, but had given up any hope of a college course because she was completely broken in health. Her essay was a scathing arraignment of our public-school course; I have been trying ever since to determine how far it was just.

Discussion of the health of the students in women's colleges is always a popular subject; has due attention been given to the physical condition of the young girls in the public schools? The public schools are of course immeasurably more important than the colleges. From the beginning of our national life great sacrifices have been made for the maintenance of our schools, sacrifices are still being made. They are expensive in money; in most of our towns no other appropriation is so large as that for education. They are also costly in the men and women that they use up, the teachers that they suck dry of health and strength and throw aside. The teachers seem to think that the work is worth their sacrifice; the tax-payers give ungrudgingly for their children. But if the physical vigor of the children or of a part of the children is one of the expenses of the public-school system, then popular education is costing too much.

The school system is a manufacturing plant and as such its efficiency is properly judged by its output—that is, its graduates. These are subject to physical examination as properly as to mental examination. The boys in the last years of the high school seem encouragingly robust. They usually take a little lower rank in their classes than do the girls, but, as they would themselves express it, they do their work 'well enough' and when their lessons are done they have supplies of unexpended energy. In athletics they show considerable endurance and many boys partly support themselves by working in shops and offices outside of school hours. In their own homes they prove active, hungry and without excess of nerves.

The condition of the average girl is manifestly different. She appears to the casual observer anæmic, flat-chested, round-shouldered and out of symmetry, and a member of her family knows that she is fickle of appetite, regularly subject to headaches, nervous and irritable. Some of the girls are frivolous, devoted to 'society' and to trashy novels; the average is conscientious about her work and almost morbidly painstaking. She worries over every lesson until it is prepared as well as she can do it, probably after that because it is not done as well as some one else could do it. Her study—and her worry—exhaust her and any other work is a burden. At best she needs complete rest after graduation; at worst she joins, perhaps for life, the ranks of the women who are not strong. A large number of pupils leave the high-school before completing their course. More boys than girls drop out, it is true, but the boys go to earn a living or because they have not met the requirements of the school. The girl very often goes by her physician's advice.

If we consult a doctor for an ailing high-school girl he makes a diagnosis and a prescription almost at sight—"over-study; take her out of school." Often he does not find it necessary to inquire about any other habits of hers except her habit of study. But is her going to school the chief factor in the girl's breaking down? If so, things were better managed in the days of our grandmothers when no girl had much public schooling after she was fourteen years old.

If a girl breaks down under a course of study on which a boy thrives does it indicate that she has less mental power? We dislike to admit it and the experience of our teachers does not in general indicate it. Why should we attribute the widely different result to the one thing that is exactly alike for both sexes? Brother and sister come into the world with the same mental and physical heritage. The girl inherits tendencies of body and mind from her father quite as much as from her mother. The boy and the girl have the same food and the same course of study. At the high-school age the development of heart and lung and brain is at about the same stage in both sexes; the girl is a little nearer to her adult weight and height. What circumstances

of their lives have been different for them? When do they begin to show differences in themselves? From a very early age there have been certain differences—in clothes, in occupation and in recreation, but these have manifestly been superficial and insufficient to account for the contrast. Very little difference appears between the sexes until they are nearly through the grammar school. Then a great change comes to the girl. "My daughter has become a woman" is the phrase which our grandmothers used to describe the epoch; and far as the callow, fourteen-year-old maiden seems from womanhood, the term is the exact expression of a vital truth.

It is at this very beginning of woman-life that especial attention is needed. We know that the boy who is overworked before he gets his growth is always an undersized man; just as surely a girl who is overworked physically or mentally during her period of puberty is always an undeveloped woman. And mental overwork is fully as injurious as physical overwork.

To speak plainly, the maturing girl must have blood and vitality to perfect the organs essential to her complete being and to establish regularly the periodic function characteristic of her sex. She must do these things at the time appointed. If she must choose between developing mind or body let her by all means choose nourishment for her physical growth. The mental expansion can come later, but the physical perfecting has no second chance. If there is lack of development or unbalanced development at this time she is pretty sure to endure suffering for the best part of her life. From careful investigation of the physical condition of a large number of girls it has been found that from "65 to 70 per cent. enter the higher institutions of learning and business with menstrual suffering of some sort." In some occupations the rate of suffering is as high as 91 per cent.

And the girl may be called upon to bear other sorrows harder than pain for a woman to endure. The injury from arrested development may not appear at once, though flat chest and narrow hips may suggest it; but when life demands of the woman that she do a woman's work she is unequal to it and is broken down in her attempt. Dame Nature, herself the representative mother, has her own idea of the function of women in the scheme of things. When they are fulfilling her purposes she gives them marvelous protection, but woe to those who try to stand against her!

Just as soon, then, as signs of change appear in the girl she should have especial care. To quote from Dr. Engelmann, "She should have personal talk and explanation from a woman who has learned the meaning of wifehood and maternity." To supplement from President Hall, "The quality of motherhood has nowhere a more crucial test than in meeting the needs of this epoch." In general the girl should have at this time no mental or nervous strain to divert nourishment from her

physical development. At best, if she is strong, does her work without worry and "normalizes her lunar month" promptly, she may stay in school without much danger provided she take her two days of rest periodically. I am inclined to believe that this is in all cases worth while until the end of the high-school course, although it is always impracticable to make general rules. A number of women who consider themselves perfectly well so far as sex weakness is concerned have told me that they believe their health due to their year of complete rest at puberty and that they did not find the need of monthly rest after the first years.

I am coming to be convinced, somewhat against my wish, that there are many cases when the girl ought to be taken out of school entirely for some months or for a year *at the period of puberty*. This course is supremely worth while if she shows irregularity of function or decreasing vitality, and it is at this time that there is profit in such an especial vacation.

I do not speak with ill-considered lightness of taking the girl out of school for a year. It is a serious matter to her at a time when she is likely to take all her life too seriously and when she should feel as free as possible from annoyance. She is naturally disturbed at leaving her class, especially if she is likely thereby to lose a grade. It is worth while to take considerable pains to minimize her distress. If she enjoys a pleasant visit out of town until the term is well under way, then returns to private lessons with her mother or some other wise teacher, lessons determined in time and length by her physical condition, she may endure her enforced vacation from public school without much fretting. The anxieties of this period ought to be borne for her as far as possible; that she should become anxious about her own health would defeat the very end in view. She can be assured that days out of school now are pretty sure to remove the necessity of days or weeks or months out of school later in her course. Similarly two days out of school every month the first year that she is in the high school in order that she may not suffer are really much better worth while than two days out of school the last of the course because she is not able to be present. These days of rest are not in the least incompatible with good work in school; a girl so cared for may be expected to accomplish more in a year than she who has no such restraint. Mothers protest again and again that such a custom is entirely incompatible with modern school demands, but I have never known a teacher to say that it was not quite practicable, and I have seen school work done under this régime to the entire satisfaction of all concerned. It is perhaps worth while to record here the questions of one grammar-school teacher —"Why will not mothers tell me when the critical period begins for their daughters? Many times I can determine for myself, but in general I could make things so much easier for the girls if I could only know when they need especial indulgence."

No, the objection to periodical rest does not come from the teacher nor primarily from the mother, but from the girl herself. Yet if our thoughtful mothers could be convinced that "the health of a girl for her whole life depends upon her normalizing the lunar month," to employ a phrase of President Hall's that I have quoted before, they would bring about the best order of things. But most mothers honestly believe that no great care is necessary. They expect their daughters to get along about as well as they did and they suppose that about so much pain is necessary for women. Mothers could hardly escape being convinced of the great responsibility that is upon them at this time if all the evidence that exists on the subject could be brought to their attention.

It is undoubtedly true that each month in a woman's life is a continuous wave with a regularly recurring succession of phases and this continuity of change makes an ingenious argument that a woman does not need especial rest at any particular time of the month. But my own observation would have convinced me that it is supremely worth while to guard an adolescent girl from nervous strain during the days when the wave of her vitality is at its lowest point even if physicians and educators had not spoken so strongly in favor of the custom. Dr. Mary Putnam Jacobi, in the monograph which she wrote to show that there is nothing in the physical nature of the adult woman to incapacitate her periodically for work, says nevertheless, "In adolescence and during the first years that the reproductive wave of nutrition is being formed mental work exacted in excess of the capacity of the individual may seriously derange the nutrition"; and elsewhere in the same paper she says, "It is curious to note how the effects of misery and the effects of luxury during the childhood of a girl are found so often to result in an identical mode of stunting during adolescence."

Much that has been written on the subject of puberty in girls has been printed only in medical and educational journals. Perhaps some women of delicacy may say that the discussion of such a matter is properly confined to medical journals. To a certain extent this is undoubtedly true; the trouble is that the average mother does not have easy access to those files. Therefore it seems worth while to quote at some length in this paper.

The idea that a girl needs especial care at her time of maturing is not a new fad of educators. In the time of Hippocrates it was noted that the period of puberty was very critical for the development of the nervous system. The rites enjoined by Moses provided for the care of the girl at this crisis and a similar provision appears in the code of Zoroaster. Savage nations to-day prescribe and protect by their superstitions definite observances for the woman at every period of her sex-life from the beginning to the end. The women of the North American Indians, always regarded chiefly in reference to their utility,

nevertheless have assured to them by custom from three to five days every month so long as the monthly law rules them.

With the present increased attention to the study of preventive medicine, students of gynecology have come to believe that the diseases of women are in good part due to their "ignorance of functional hygiene." In 1908 Doctor Engelmann gave as his president's address at the annual meeting of the American Gynecological Society a paper, "The American Girl of To-day," which entirely covers this subject from the physician's point of view. In brief his opinion as there expressed is: "Adolescence is the most important period of a woman's life, the period during which the foundations of future health are laid. It is in this period of school, the beginning of social life, the period of learning in trades that the nervous energies of the female are most fully engaged and her activity is concentrated on the brain to the detriment of other functions, above all the developing sexual function, the central and most important and at that time the most easily disturbed."

Dr. Wylie has expressed his opinion that "the American horse receives on the average better treatment than the young women of America from the time of early girlhood until the age of development is passed."

President Clark and Professor Tyler have studied systems of education with especial reference to the physical development of children. In his book 'Adolescence,' President Hall devotes a long chapter to the subject of 'Periodicity.' He is himself convinced that the health of a woman for her whole life is determined in her days of adolescence, and he cites so many witnesses, ancient and modern, learned and savage, that the most unbelieving reader can but be convinced while she reads.

Professor Tyler, as a student of biology and education, has considered what bearing the laws of growth have upon the proper arrangement of courses of study. In his lectures on 'The Physical Basis of Education' given last winter in Boston before the Twentieth Century Club he said, concerning the development of girls during their school years, "At the critical period of puberty almost every organ in the girl's body is affected. [The girl's] pubertal period is much more likely to be stormy than the boy's and her rate of morbidity is considerably higher. Her future health and happiness, if not her life, depend upon the successful completion of the metamorphosis."

A valuable addition to our knowledge of schoolgirls has been made by Dr. Helen Kennedy. She collected statistics of the habits and the health of girls from a large city high school; her article includes her questions and the answers of the students, so that we may draw our own conclusions. We note that while nearly all the girls report themselves as growing no worse during their high-school course, 97 out of the 125 say that they suffer to a greater or less degree. All Dr. Ken-

nedy's results are interesting and full of suggestion, and much light upon the health of our women would come from further investigations along these lines. From her data and that of others, it is to be noted that most girls between sixteen and twenty suffer more or less; and that alike for students and working girls the percentage of sufferers increases during that time.

My belief that most girls have the foundation of their suffering laid before they are sixteen may be unwarranted, but I have found no data that contradict it. Quoting again from Professor Tyler, "The critical period in a girls life is evidently the years between ten and fifteen, earlier than most of us think. Most of our care and thought is devoted to locking the barn door after the horse has been stolen." And once more, in the phrase of Dr. Engelmann, "the younger the girl, the nearer the period of puberty, the more impressionable the system, the more susceptible to influence for good or evil and most harm is wrought in the first year of functional life." I quote much from Dr. Engelmann, but where can I find better authority, especially in this particular phase of gynecology?

I have given a large part of my discussion of the health of our girls to a consideration of the demands of sex at adolescence, but perhaps this extent in treatment is not disproportionate to its importance in their lives. When a girl is safely guided "through the breakers of puberty" we have some reason to expect for her life-long vigor and the power to do. But she needs also through the rest of her school days intelligent direction in other respects. It sometimes seems to the teacher that she does not get quite as much as she needs.

The teacher is expected to see all that goes on in the schoolroom; in addition to this she does see evidences of a great many things that go on outside the schoolroom, things which, though they largely affect the results of her work, she has little power to modify. The personal habits of a girl determine to a great extent what she is able to gain from her course of study. If it is important that her nourishment be directed at all times to the most immediate needs of her body, surely it is no less important that there should be sufficient nourishment to satisfy these needs.

Every girl knows that this sufficiency of nourishment is impossible unless she assimilates plenty of food, but she does not always make her knowledge evident in her habits. Very often the high-school teacher is asked to excuse from the session, on account of headache, some girl who admits when questioned that she has eaten no breakfast that morning. It is possible for the teacher to point out to the girl the folly of starting a locomotive for a day's run without providing fuel, but the girl must have some pressure brought to bear upon her at home if she is to take sufficient time for her meals. Insufficient breakfast is

often due to late rising; if the girl has not time enough to dress and to eat, it is not the dressing that is hurried.

With the usual five-hour high-school session the girl needs at recess a proper luncheon. If the school has a lunch counter where only suitable food is provided, then it is well, but in case the luncheon comes from home the teacher often wonders whether the mothers are accessory to the mince and lemon pies and the fruit cakes that make the daughters unfit for study. At the end of the long session the girl comes home with little appetite or power of digestion. In a working-man's family dinner was served more than an hour before, and the plateful of food that has been kept warm for the daughter is hardly palatable; probably she makes her meal chiefly out of the dessert. It is tremendously worth while for the mother to preside personally at this meal of her daughter and always to have tempting, nourishing and easily digestible food ready for her when she comes home from school.

The blame for a high-school girl's dyspepsia is often attributed to the one-session system; and under that system a bad order of things is easy, as we have seen. On the other hand, with one session very much better conditions are possible than with two if the best use is made of the time out of school. It ought to be possible for the greater part of the pupils to work under better conditions at home than in most schoolrooms; and when they are in school until four there is little time for being out of doors in the sunlight during most of the school year.

The girl who is insufficiently nourished craves abnormal things and eats sweets and sours in unsuitable proportions. With all these sins against her digestion much of her food is not assimilated. Very often the waste is not properly eliminated; the girl does not realize that this condition is a menace to her health and so her whole system is poisoned. Constipation is a disease and the cause of many others; it is entirely incompatible with perfect health or good work in school.

At least one strong article has been written—by a physician—to maintain that women's mode of dress is a sufficient cause of all their physical distress. Undoubtedly it has been responsible for great injury, though present conditions are much improved, so far as tight or long clothing is concerned. We appreciate, however, that women are still handicapped when we see how their ordinary clothing hampers them in gymnastic work. Just at present school girls expose themselves to the cold in a way unsuitable to this climate. Even in winter they go to school bareheaded, in lingerie waists with light undergarments, cotton hose and low shoes. The toughening process is valuable to a certain extent, but such exposure as this means an expensive strain upon vitality. School girls are notably careless of wet clothing and wet feet. Mothers have difficulty in persuading them to overshoes and rain-coats, and teachers find them unwilling to go home when skirts and stockings

are wet through. To sit in wet clothing is dangerous even for an adult woman.

This paper is intended to deal especially with those elements of a girl's life that are detrimental to her health, yet are usually overlooked. It is hardly necessary to include much discussion of the need of sleep. Every one understands that a girl needs about nine hours of sleep in pure air. At present there is a general enthusiasm among young people for outdoor air. If they do not take sufficient sleep it is not because they do not know the need of it.

The recreation of a girl ought to do something toward her re-creation, not leave her more exhausted than all her work. But those who have studied the physical development of the girl tell us that the excitement and nervous strain of society and late hours are much more exhausting than hard study for a young girl. This does not mean that she should give all her time to her lessons, only that her amusement be something less wearing than study. She ought to have good times, she is the better for parties if they are limited to reasonable hours and to suitable companions. One element of a high-school girl's life which is seldom mentioned, but is often noted by her teacher, is the detriment that comes to her from social intercourse with those who are a few years older than she, especially with older men. If a girl spends one or two evenings a week in the cultivation of such friendships as these and reads a romantic novel every week it is to slight profit that she spends the rest of her time "over her books." It is pretty nearly impossible for her to concentrate her mind on her work.

It is a very common criticism that there is too much social life in the school itself. It is admitted, at least in this country, that children need some amusements. *If other social distractions could be omitted* what could give a school girl more harmless pleasure than the class dances and parties, under the direction of a teacher-chaperone, parties that include only people of her own age and experience and that close at a proper hour?

A girl's real re-creation is her out-of-door sports and she should receive every encouragement to those that she most enjoys. The implements of such sports—golf-sticks, tennis racquets, boats and skates—are better investments for parents' money than even pretty clothes, if there must be a choice of expenditures. Housework is one of the best possible forms of exercise if done in well-ventilated rooms; it might be profitably taught by mothers under the name of physical culture.

Music study is, I believe, hardly to be classed as a recreation, even though it happens that the pupil enjoys it so much that it does not appear a burden. It is mental work requiring close attention, memory and some eye strain. It makes about the same demands as an extra course in school, and if it seems best for the girl to continue much piano-prictise during the term, she should take five years for her high-

school course. Often a collapse in school that seems inexplicable to the teachers is due to a pupil's adding an hour or two a day of piano-practise to an already full school course. It is worth while for the girl to take music lessons during the summer if she is within reach of piano and teacher; the discipline and regularity are a good thing during these weeks of complete freedom.

Many pupils suffer from eye-strain; every possible care should be taken at home to minimize this, both for the sake of the eyes and for the direct influence upon the mind and temperament. Study before breakfast is very likely to aggravate eye-strain; if there must be early study the pupil should bathe her eyes in cool water and take some food, that the congestion of the eyes may be relieved. A proper light lessens the fatigue of the eyes. By day the student should not face the window and at night her lamp should have an opaque shade. Often the change from a white to a dark-green shade relieves long-continued pain in the eyes.

Reference has been made to a girl's spending time "over her books," and the phrase is sometimes especially accurate. Instructors of college freshmen complain that boys and girls go through preparatory school without having learned how to study. The teachers may be responsible for a part of this, but there are some conditions that the most devoted teacher can not govern. She can regulate a pupil's work in school, but when much of the study must be done at home the home must help in establishing good habits of work. A student needs a well-lighted work-room reasonably free from interruption. It is not necessary that the window have an extended outlook; a girl is likely to establish herself for her afternoon's study where she can get a wide view of the street. With a little attention the daughter of the house may be helped by her surroundings at home to a concentration upon the work at hand that will lessen marvelously the hours that she must spend with her books and give her more time for recreation.

Elements internal and external, elements physical and mental, have been treated together in this discussion and inevitably so, for they are almost indistinguishably interwoven in the life of the girl. How much her health of body depends upon her health of mind no one can venture to say. One feminine characteristic becomes especially evident in the adolescent maiden which has considerable influence upon her health. This is the narrowness of mind that causes her to give undue importance to really minor elements of her life. She comes to believe that there are only two or three things in the world that are really important; if she is an only child she may decide that there is only one. It is undoubtedly desirable that a girl stand well in her class and wear attractive gowns, but there are other things just as essential. When she sees that it is worth while to hold fast to "a taste for simple pleasures" and to promote the happiness of her family and community, and

supremely worth while to make herself an able woman physically, she is well on the way to the attainment of a poise of mind essential to her health and to her breadth of thought. Much of her narrowness may be eliminated by the public school and that very effective education which a child's companions supply. But there are certain chambers of a maiden's mind especially suitable for her mother's furnishing; in the most intimate relations of a girl's life she must naturally find her direction at home.

And is not this the conclusion of the whole matter? Undoubtedly the girl does need "the complementary wisdom of school and home," and sometimes when every precaution is taken at home the school work may be too hard for the girl at some particular time. In this case the parents must lay the matter before the teachers; in some way the work must be lessened, so that a growing girl does not come through each week exhausted. But in most cases it is found that it is not the *work* that exhausts.

The American girl needs the public school. She needs it for its democratic influence, really a powerful element in the mutual understanding between women, which alone can solve the "servant problem"; she needs the acquaintance with boys of her own age which banishes sentimentality; she needs the broadening influence of men-teachers. It does not seem on the whole that there are many points in which the school can do more for the girl than it is doing; it is not in general conditions that she needs more consideration. For it is true that "the teacher has to deal with the average; the parent must accommodate the particular," and that "it is to the parent that the child must look for his (and her) individual protection and care."

In brief, as soon as a girl comes to manifest her difference of sex, she needs especial and intelligent protection at home to free her from strain mental and physical. And when her health and future fulness of life are thus established, they must be guarded by continued oversight of her food and clothing and exercise and recreation and sleep. Her mental and nervous strength must be conserved by guiding her into orderly ways of thought in the personal and intimate matters that obviously do not belong to the public school. When these elements of her life are properly administered at home the American girl can in ordinary cases complete the course of study in the public schools without injury to her health.

The articles to which especial reference has been made are:

"Rest during Menstruation": Dr. Mary Putnam Jacobi.

"The American Girl of To-day": Dr. George J. Engelmann.

Article in New York *World:* Dr. W. Gill Wylie.

"Adolescence": President G. Stanley Hall.

"Effect of High-school Work on Girls during Adolescence": Dr. Helen Kennedy.

SOME ETHICAL ASPECTS OF MENTAL ECONOMY

By Professor FREDERICK E. BOLTON
STATE UNIVERSITY OF IOWA

TO be economical of one's powers makes for efficiency; to be prodigal, makes for inefficiency. To be efficient in life is the highest ethics. To be inefficient because of prodigality is to be immoral.

It will be observed that in this discussion I follow the Aristotelian conception of ethics as a practical science, rather than as a theoretical science. The object of the discussion is to consider certain modes of mental life, to evaluate them, and to offer a few guiding suggestions for the proper conduct of life.

Professor Paulsen has compared this view of ethics with the science of medicine, which he says, "instructs us to solve the problems of corporeal life, to the end that the body may perform all its functions in a healthy manner during its natural existence; while ethics, basing itself on the knowledge of human nature in general, especially of its spiritual and social side, aims to solve all the problems of life so that it may reach its fullest, most beautiful and most perfect development. We might, therefore," he concludes, "call ethics universal dietetics, to which medicine, and all the other technologies, like pedagogy, politics, etc., are related as special parts, or as auxiliary sciences." ("A System of Ethics," p. 2.) The purpose of ethics, then, is "to determine the end of life, or the highest good, and to point out the way or the means of realizing it."

This much by way of definition is given preliminary to my discussion of mental economy as a phase of ethics, in order to justify my treatment when I seem to digress from the immediate consideration of right and wrong and to discuss questions which might properly be also catalogued under pedagogy or mental hygiene.

All will agree that no life is most nobly lived unless it has secured the complete unfoldment of the richest inheritances bequeathed by ancestry; unless it has appropriated environment in such a way as to secure the limits of individual advancement; unless it has rendered the utmost possible service to society. To fail in these particulars is to be prodigal and uneconomical. To be uneconomical is to be unethical. The world is full of work to be done, problems to be solved, which are of proportions never before assumed. To meet these duties and responsibilities requires the highest products of intellectual evolution, keen and broad sympathies, and vigorous, sustained will-impulses.

To live completely and ethically, every one should accomplish more

than his parents. This means not only that he should secure more tangible results, but that he should develop and expend more force than his ancestors. Each one stands on the shoulders of the past and may utilize all the accumulations of the past. In order to accomplish more than our forefathers, it is absolutely necessary, however, to husband our forces. But with the increase of potentialities, we must also reckon with the fact of the manifold additional ways inviting and exciting to depletion of powers. As an illustration, let us note the excessive stimulation to which the eye is subjected. In our present civilization we have come to depend more and more upon vision. The strain upon the eye in gaining knowledge of the objective realities about us has been increased a thousandfold by modern modes of travel. In addition, we must use the eye to interpret language symbols about myriads of things inaccessible to personal inspection. Primitive man had only a narrow range of things to see, and those usually at some distance. Hence he knew not of eye strain resulting from the microscopic scrutiny of a vast kaleidoscopic scene. Formerly man could deliberate in seeing the few things within his range. But now he becomes a globe-trotter, compacting into a few weeks the view of scores of nations, vast expanses of country, the collections of ages, and the unceasing activities of the heterogeneous throng.

In a week's jaunt and doing a world's fair, present-day man sees more and hears more, than was possible in a whole lifetime, a century ago. Besides these activities the eye is made to do duty in reading the twenty-four-page daily, the forty-eight-page Sunday edition, in scanning a half-dozen weeklies, going through a cartload of magazines, to say nothing of all the latest books which one is supposed to read.

The ear is equally assailed with the ceaseless hum of voices, door bells, telephone calls, whir of the trolley, the shriek and clang of the locomotive, the maddening grind of the sleeping car or the twin-screw steamer (upon which we take our vacation rest!), the deafening roar of the factory, the clatter of galloping hoofs and rattle of wheels over paved streets. Even at night we must be assailed, business must not stand still, goods must be sent by return mail, limited trains must outdo lightning specials. Even on Sundays we are not permitted to listen to restful sermons—they must be such as to give rise to glaring head-lines, and the music is often of ear-splitting pitch.

The first and foremost great law of mental dietetics that should be impressed early and often is that one long ago stated by Juvenal, viz, *mens sana in corpore sano.* Every parent and every teacher should understand that the first business of the child is to become a good animal; childhood years should be largely vegetative. His primal inheritance is physical. To have big lungs, firm muscles, elastic step, ruddy cheeks and scintillating, unspectacled eyes, and every sense alert, at the close of youth are priceless possessions with which a knowledge

of algebraic formulæ and a few dates in history are not to be compared. For what shall it profit a man if he gain the whole world of knowledge and have not physical power to use it?

Not only is a sound body an absolutely necessary correlate of a sound mind, but mental processes themselves are incomplete without muscular accompaniments. How vague would be our ideas of walking, talking, writing, painting, molding and chiseling without the muscular accompaniments. You can not even think hard of a word without involuntarily moving the muscles. Try it sometime by opening the mouth and thinking the word bobbin, bubble, etc. So-called 'mind reading,' table turning, the planchette, all illustrate the same fact.

Again, the body possesses all the gateways to the soul through which all knowledge of the outside world must come. Close the eyes, stop the ears, and deaden all the other sense-organs and the child is mindless—an idiot. Finally, no message can issue from the mind, nothing of its workings can be revealed and no control of the world forces be secured, save through the medium of physical organs—the muscles.

Consequently, to secure the highest mental efficiency we must give due consideration to bodily culture. Any education which disregards this is a failure. Every student should have sufficient food, adequate sleep, proper exercise, abundant recreation and in every way seek to promote bodily vigor.

The Socratic doctrine of innate ideas has been responsible for many pedagogical sins. Socrates taught that the business of teaching was to draw out these inborn ideas. The middle-age ascetics went so far as to assert that spiritual development could be best furthered by bodily torture. Consequently, in order to elevate the mind they strove to devise tortures to crucify the flesh. We read of their fasting, eating inappropriate foods, going barefooted and otherwise scantily clad in the dead of winter, wearing hair shirts with the hair inside; bathing in ice-cold springs in winter, sitting on sharp nails, assuming unnatural and extremely uncomfortable postures for months at a time, binding the body with ligatures, loading the body with weights, living in filth, going without sleep and working all day and all night, etc. Simeon Stylites is said to have lived for forty years chained on the top of a high pillar and Macarius slept for months in a marsh, exposing his naked body to the stings of venomous flies, in the misguided notion that the greater the bodily penance the more exalted the spirit became. In fact they tried to devise every possible means of excruciating torture of body in the attempt to exalt mind. To this pernicious doctrine of the relation between body and mind can be traced much of the long intellectual night of the middle ages. To it are directly traceable the beliefs in witchcraft, demonophobia, sorcery and the

superstition that insane people were possessed of evil spirits. Professor Monroe ("History of Education," p. 248) says, "the virtue of the monk was often measured by his ingenuity in devising new and fantastic methods of mortifying the flesh—all these forms of discipline were for the sake of spiritual growth, the moral betterment of the penitent: all these, as the very significance of the word asceticism indicates, reveal the dominant conception of education which prevailed throughout this long period,—the idea of discipline of the physical nature for the sake of growth in moral and spiritual power." So long as the body was considered gross and evil and a mean tenement of clay from which the spirit should strive as soon as possible to escape, it was but natural that bodily care, and much less culture, should be considered unworthy objects of education.

Sleep as a factor in student life does not receive adequate consideration from many students. The student who does not take regular and sufficient sleep is pilfering his own bank account. There is absolutely no substitute for it, and when once lost, restitution can not be made even by a nap in the class-room. Nervous tissues exhausted by a day's activities can only be restored by sleep. Dr. Hall says that no child should be allowed to go to school without having had nine hours of sleep and a good breakfast. This would not be a bad rule to guide student life. Parties, athletic jaunts, examination crams, and even working for one's living, which cause students to remain awake beyond the midnight hour, transgress all laws of mental and physical hygiene. There is doubtless no cause so frequently producing nervous breakdown as loss of sleep. Several former students who were pale and anemic while here have returned after a hard year's teaching experience with ruddy complexion, increased weight and all the appearances of vigorous health. I have inquired concerning the change and have been answered, "I guess it is because I get enough sleep now."

The student who goes to college to become a hermit, not touching elbows with his college mates and developing no interests through hearing music, attending lectures on varied subjects, seeing nothing of the great busy world about him, misses a vital factor of college life. His procedure is uneconomical and therefore unethical, for when he emerges from the college halls into the busy, bustling world, he will find himself behind the procession. Because he has not seen the larger world while acquiring his book knowledge, he perceives no relation and often feels that the world is somehow out of joint because it does not conform to his bookish ways. To become efficient he must begin again and study the world about him. He must gain its view-point, adjust himself to it; he must now try to gain friendships which should have been established in college. All this is a wasteful, selfish process.

On the other hand, some students need to be cautioned when they make the opposite and equally grave error of saying that "My asso-

ciates teach me more than my books and class work." Possibly they do, but it is not the fault of the books nor of the classes, nor any compliment to the associates. He says, "I study men, not books." This is sound, if rightly interpreted, but he should know that there are some men besides freshmen well worth knowing. Some of them can only be known by going to their books. He should learn to study individuals as well as masses, the world's teachers as well as his own classmates; he should look up as well as around. The college course is certainly a failure if it has not given the student lasting acquaintanceships with a few superior students, some great men on its faculties, and many of the world's intellectual élite, who can only be known through the pages of history and the great literatures of all ages. Great ideals which become guiding stars of one's destiny should be clearly glimpsed. The great laws of science should have banished superstition forever from his mind and given him a new interpretation of universal development and history. Finally a clear conception of philosophical principles should act as a great balance wheel enabling him to interpret life and all its manifold activities. It is through books and master minds that the student should get meaning for all his varied observations and activities. To regard books and class work as inferior and something to be endured is to miss the whole point of a college education. Colleges are founded and maintained for the specific purpose of furnishing books and teachers, and all class work, once selected, should have the right of way. Student programs should not be so overloaded but that all the accessories may be duly emphasized. Recreation as well as work should become a part of one's religion. The gospel of relaxation needs evangelists as well as the gospel of work.

It is important for the student to understand early the force and value of habit. Much time is lost by every one of us because our early training did not render automatic all those activities that we have to perform constantly and in the same way. Purely mechanical work can be controlled more economically by lower nervous centers than by higher. In childhood and youth the nervous system is plastic, a prime condition for memorizing and fixing habits. Among the habits that should become ingrained during this period are those of correct bodily postures and activities, correct speech, the multiplication table, spelling, writing, those involved in learning to speak foreign languages, etc. Most habits are controlled by the spinal cord, which is early developed. Hence we should form habits early, so that the brain may be relieved later of mechanical work and be concerned with higher operations. As Dr. Balliet has observed, "At first a child uses his brain in walking, later he can walk from habit and walks therefore with his spinal cord. As first we spell with painful consciousness, later we spell familiar words of our vocabulary with little

or no consciousness. Children ought to be trained to write and spell mainly with the spinal cord, and use all their brain power in thinking the thoughts to be expressed. We do many things with the spinal cord to relieve the brain. We walk with the spinal cord, we write and spell with the cord; I suppose we knit and gossip with the spinal cord; indeed we may sing and pray, not with our hearts, nor with our brains, but with the upper part of our spinal cords. We tip our hats to each other, not with our brains, but mainly with our spinal cords; when we meet people whom we do not wish to see, we often shake hands mechanically with our spinal cords—hence we speak of a 'cordial welcome.'"

Not only do these elementary physical activities become automatic, but also processes of judging and reasoning must become largely mechanical before becoming serviceable. One's thinking is largely specialized and judgment outside of the well-beaten track of thinking is not very valuable. The lawyer's opinion concerning disease is slowly formed and unreliable; the doctor's judgment about legal matters likewise is valueless. The expert in a given line is one who has studied widely and who can form instantaneous judgments because of the habitual consideration of the data. Difficult studies pursued through a long time until mastery is complete become as simple as the alphabet. Mathematicians become so familiar with the calculus that they read it for recreation when fatigued with other work. The lawyer can instantly cite scores of cases and precedents for which the tyro would have required hours to summon to the foreground of consciousness. Hence, when knowledge is to become usable it must be pondered long and every detail absolutely appropriated. To arrange work in such a way as to sustain interest through variety and at the same time dwell upon it until thoroughly comprehended and appropriated is high teaching art. The demands for variety frequently allure to new fields before assimilation has been effected.

Even the will is much more a matter of habit than we usually think. It is too often regarded as a sort of psychological ghost which pursues us about, compelling us to do certain things and prohibiting us from doing certain other things. Every one is supposed by the popular mind to have at birth a will of unchangeable quality and quantity. This is absolutely incorrect. The child has impulses but is practically willless. His will must grow and develop like any other powers. We use the will when we perform actions which we control. When we lack control, either muscular or mental, we lack will, or possess a diseased will. When a child can pick up a pin, thread a needle, tie a knot, walk without tottering, run, talk plainly, etc., he manifests definite mental and muscular control and therefore manifests voluntary power.

Now these activities were only possible after long practise and the development of definite habits of activity. As Dr. Royce says, "Our

minds become full of impulses, of tendencies to action, of passions, and of concerns for what we take to be our welfare. All these impulses or concerns get woven by the laws of habit into systems of ruling motives which express themselves in our regular fashions of conduct. The whole of our inner life viewed in this aspect appears as the purposive side of our consciousness, or as the will, in the wider sense." We even need to put new interpretation upon the meaning of the freedom of will. Freedom means power of choice, power of desire, but not necessarily power of execution. The life-long habits of every individual chain him down to certain types of action and it often takes long practise to break up fixed customs and habits of activities. This has its sad side and also its advantageous side. Were it not that we willed with all previous acts of willing, and were it not true that all our habits hold us to certain types of action, it would be impossible to predict what the individual might do on a given occasion. When we analyze the meaning of character, we find that it implies nothing more or less than the accumulated tendencies toward action in particular directions. The man who has habitually acted in a righteous direction has built up tendencies toward righteousness. On the other hand, one who has sown a generous supply of wild oats in youth is sure to reap in old age an abundant harvest of viciousness. It could not be otherwise. We are enjoined in the Scriptures that 'whatsoever a man soweth, that shall he also reap.' A prose-poet has stated that "we sow a thought and reap an act; we sow an act and reap a habit; sow a habit and reap a character; sow a character and reap a destiny." Professor Fullerton says that the old interpretation of absolute freedom would make this a melancholy world. In such a world of freedom no man could count upon himself and no man could persuade his neighbor.

We should be powerless to lead one another into evil, but we should be also powerless to influence one another for good. It would be a lawless world with each man cut off from the great whole and given a lawless little world all to himself. He said, "To-morrow I am to face nearly one hundred students in logic. It is a new class. I know little about its members, save that they are students. I have assumed that they will act as students usually do and that I shall escape with my life. If they are endowed with free will in the old interpretation, what might I expect? What does free will care for the terror of the dean's office, the long green table, and the committee of discipline? Is it disinterested in logic and does it have a personal respect for me? The picture is a harrowing one and I drop the curtain upon it."

Hence, from a pedagogical point of view, how important to fortify the child by habits against that which is undesirable in conduct by developing in him impulses and tendencies through experience in right conduct. Right conduct in children there must be if we expect right conduct in adult years. The man who has to reflect to keep his hands

from his neighbor's pocket does not possess honesty of a very high type. It is only the one who possesses no impulse to pick his neighbor's pocket and who does possess an instinct of abhorrence against such an act that is really honest. The one who is tempted evinces disease of will.

Independence of thinking is a rare but thoroughly economical mode of activity. Many people are so unused to thinking for themselves that they would be frightened at the appearance in consciousness of a thought really their own. It has been said that "animals think not at all and some men a little." Most of the thinking of the world is carried on by a few individuals. The rest of the world are mere echoists. This is a terribly wasteful process, and sinful. If more people were independent thinkers there would not be a yearly output of millions of barrels of patent medicines, the main ingredients of which are alcoholic preservatives. Soothing syrups with opiates are fed to children because they are said to cry for them. The children are quieted, oftentimes so effectually as to be stupid through life. "Harmless vegetable remedies" is a magical phrase. Perhaps this is why so many take extract of hops and barley, spirits of corn, nicotine and opium!

Because of lack of independence of thought, superstitions have always hindered the world's progress. Even to-day the number 13 is so ominous that you can not get a room number 13 at a hotel, can scarcely have 13 at table. Friday is still considered so unlucky that steamship companies hesitate to make sailing dates on Friday. Farmers still plant their potatoes in the moon, and men carry potatoes in their pockets to cure rheumatism. Only a few days ago I saw a man in this city who had a rattlesnake's tail in his hatband to ward off rheumatism. Clairvoyants and fortune-tellers apparently find plenty of dupes, if we are to judge by the wealth of their advertising. Thus on every hand we find ample evidence that people are sinning and being sinned against simply because of slothfulness in thinking.

In ancient times and in the middle ages the scholars shut themselves away from the world, quiet as it was, in order to avoid the distractions against thinking. While they erred in not recognizing that the senses are the source of all knowledge, were they not wise in recognizing that to think effectively demands solitude?

I wonder if there is not much in modern student life that militates against the deepest thinking. With the multiplication of student activities, of themselves in no way secondary to any others in importance, have not the opportunities for sequestered contemplation decreased? With football, baseball, basketball, tennis, rowing, skating, the literary society, the dramatic club, the freshman banquet, the sophomore cotillion, the junior prom, the senior hop, numberless fraternity, sorority, and various other house parties, the various church,

social and other engagements, besides the loafing hour, the theater, concert, special lectures galore, the newspapers and magazines to scan, the letters to write home and other places, applications for schools to make, etc., one might well exclaim, "And when do they find time to study?"

Many students take on altogether too many activities. In my own observation I have known several students who arrested their development badly by getting too many irons in the fire. A student's popularity is not infrequently the cause of his intellectual arrest. By attempting debates, athletics, dramatics, study and society, all at the same time, his energies are dissipated, his growth stunted, while his plodding companion by everlastingly keeping at a few things finally becomes a master and frequently astonishes even himself as well as his acquaintances. Even short courses with too much variety, except for inspiration, are uneconomical, because they do not lay permanent foundations. Too many open lecture courses provided by faculties may easily be distracting and a source of dissipation. The student must learn to say no to the siren's voice which continually beckons him on to new fields.

I sometimes feel that there ought to be some course labeled "thinking" in which the individual should be isolated from everybody long enough to really empty his mind of all ideas which are merely echoes, and then to discern what are really his own. With all the distraction of congested social life, the time may come when it would be a blessing for the state to imprison a few great men each year and allow them only pen, ink and paper. It may have been a fortunate thing for the world that John Bunyan languished in prison until his thoughts had had time to germinate and come to full fruition. Possibly the blind Milton, shut away from the distractions of visual stimuli, may have looked within and discovered thoughts struggling for expression, but stifled with ephemeral ideas of sense perception.

While we are rightly emphasizing group activities as an aid in developing altruism, I wonder whether students do not sometimes misinterpret its meaning. Self-activity is fundamental in the process of acquisition of knowledge. No knowledge is of much value that is not made one's own personal possession. This means more than the recital of words and formulæ gained from books and companions. In their desire to be helpful I sometimes see students in groups, even sitting on the stairways when the crowds are passing, believing they are *studying* together. When one hears the bits of gossip interspersed between the formulæ, the declensions and historical dates one wonders where the calm reflection, deep concentration, analysis, comparison, doubt, contemplation, deliberation, complete abstraction, enter in.

An oversocial room-mate who persists in retailing the gossip of the day during the hour set apart for study is an uneconomical acquisition.

Psychology has thoroughly demonstrated that we can consciously attend economically to only one set of ideas at a time. Even much note taking in class is an uneconomical distraction. The faithful but misguided student frequently attempts to take down every word uttered. He deceives himself, for what he hopes to carry under his arm he should have in his head. No wonder that sometimes the less scrupulous one who cuts classes and borrows notes instead of writing them fares about as well.

In student life it is important to thoroughly master a task as speedily as possible. To skim over a lesson and leave it without mastery is wasteful. The process may be repeated a dozen times in this way and then be only half learned. Hence, "whatsoever thou findest to do, do it with all thy mind and with all thy heart and with all thy strength." In mastering things for keeps two attitudes are necessary—interest and attention. Attention is the mother of memory; interest is the mother of attention. Hence, if you would secure memory, you must capture the mother and the grandmother. It is the business of us all to be interested in what we do, and it is unethical to regard our work as drudgery. I sometimes say to students, you never will be great successes as teachers until your work has come to occupy all your waking moments and even your hours of sleep. It must be your life. If you wish to know what you are interested in just catch yourselves suddenly occasionally, when you have no prescribed task, to see what you are thinking about. Those great dominating, insistent ideas indicate your real interests.

May I say a word on the ethics of cramming for examinations? The method is a delusion and a snare. Ideas are not grasped, associations are not made, brain tracks are not made permanent, and even though the student might pass an examination on such possessions, like the notes of an insolvent bank they are found to be worthless trash when put to real use. Instead of wisdom more to be prized than fine gold, such a process may leave one with only bogus certificates. Make your mental acquisitions absolutely your own while going over the subject day by day, take ten hours of sleep before every examination day, and the results need not be feared. In trying to make possessions most permanent and most economically I give frequently the following recipe: Study your lesson as if you expected to teach it. When you can teach it to some one else you possess it. Frequently actually try to teach your lesson. If your room-mate will not submit, inflict it upon an imaginary pupil. Some one said, "I do not lecture to instruct others, but to clear up my own ideas."

Although young shoulders should not become bowed down by an overweening sense of responsibility, yet it is sinful not to impress the young with the importance of the morning of life. The old adage

that it is never too late to mend should be replaced by the one that it is ever too late to become what one might have been, if an opportunity has been allowed to slip.

Students should early recognize the importance of making the most of the morning of life. Biologists have come to recognize the economic value of the period of infancy. The period of infancy is the period of plasticity, the period when the individual can be molded and modified; in other words, educated. The longer the period of infancy, the higher the degree of educability. The newly-hatched chick has a short period of infancy. On emerging from the egg, it can perform almost all the activities which it will ever be able to perform. It has very little to learn, very little possibility of learning and very little time in which to learn. The young dog has more to learn, a longer period in which to learn it and larger possibilities of acquiring new activities. The human being has the longest period of infancy. By infancy I do not mean alone the period when the child is in the cradle. Biologically it includes all the period of life from birth to maturity. It is the period of plasticity, the period of educability. After this period, the possibilities of education grow less and less. Perchance there are freshmen who may peruse this. I desire to give you a few words of comfort. You may be frequently derided by the learned sophomores who call you "greenies" or "freshies." Take comfort and regard the appellation "freshmen" as a mark of honor rather than derision. To be fresh or to be green means that you are still growing. All should wish to be green and to grow as long as possible. May you live to a green old age. Even the sophomores are all right. Woodrow Wilson said, "A sophomore is one in whom the sap is rising but it has not yet reached his head. He will eventually mature."

Professor James says that one seldom gets an entirely new idea into his head after thirty. After that period one may erect a splendid structure upon the foundation already laid. But if any subsequent structure is to be reared the proper foundation must have been laid before that time. For "outside of their own business," says James, "the ideas gained by men before they are twenty-five are practically the only ideas they shall have in all their lives." We can not get anything new, for disinterested curiosity is past, instincts have died out, bonds of association have become fixed, "mental grooves and channels set, the power of assimilation gone." Hardly even is a foreign language learned after twenty spoken without a foreign accent. "In most of us, by the age of thirty, the character has set like plaster, and will never soften again." The most possible should be made of early life, for, although it is a fact that the number of cells in a given brain is complete at birth, yet mental exercise must determine the number that becomes fully developed. Moreover, the period for development lies largely between birth and maturity. It is the period when nerve

matter is plastic and when growth and replacement exceed disintegration.

Brain workers do their best between the ages of twenty-five and forty-five before that they are preparing for work, after that their work, no matter how extensive, is largely routine. Lawyers and physicians do much of their practise after forty, but the learning was accomplished before forty or forty-five. Successful merchants lay the foundations for wealth and success in youth and middle life. The great men that we know are all old men; but the foundations for their greatness were laid when they were young. Philosophers have founded and announced their systems in youth and early manhood; divines and religious teachers have originated their creeds and have been most effective as preachers in early manhood.

Statesmen have projected their greatest acts of legislation, diplomacy and reform in early life. In the morning of life scientists have wrought out their data and practically formulated their theories; generals and admirals have gained their greatest victories; lawyers have paved the way for leadership at the bar, physicians have laid the groundwork for their greatest discoveries, poets and artists and musicians have planned and in many instances executed their greatest masterpieces.

You, young men and women of the colleges and high schools, are picked individuals. A process of selection and sifting going on for many years in your own lives, and for generations in your ancestors, determined who should go to college. The state endows its universities to enable its intellectual élite to secure the development which their native worth makes possible. The function of the school and the university is not to create brains, but to mature them. The school is like a problem in multiplication in which the student is the multiplicand and the institution the multiplier, and, as in mathematics, if we have significant figures for our multiplicand the result is significant, but if we have ciphers for the multiplicand the result must be zero.

Your efficiency in life depends largely upon your physical and mental health and your habits of work, rest and recreation. To conserve your inborn potentialities and to multiply your talents is not only a high privilege but your greatest immediate duty. To fail is to be morally culpable, to succeed betokens true wisdom and virtue. No worthier object of contemplation can occupy your mind than the Socratic admonition, "Know thyself."

THE CHINAMAN AND THE FOREIGN DEVILS

By CHARLES BRADFORD HUDSON

DETROIT, MICHIGAN

THE ancient examination halls at Peking have been transformed into a military school. To the western mind there is nothing startling in the item, nor significance beyond the fact that it suggests that China is at last rousing from her centuries of complacent introspection and retrospection, and purposes to learn something which the rest of the world has found useful. A mere change in the curriculum of certain Chinese students, it would seem, of less interest to mankind in general than if Oxford should suddenly abandon the study of divinity or the humanities. But to the Chinaman it means more. It is a change of greater moment, more revolutionary than would be the overthrow of the Manchu Dynasty. Indeed, a dynastic change would be comparatively an insignificant and commonplace event. In the fourteen hundred years since the course of studies was prescribed by which the Chinese student fits himself to enter the aristocratic order of the literati, and thereby to become eligible to government office, the celestial empire has undergone a full score of revolutions, each one of which has resulted in the establishment of a new royal line. But during that period, which has witnessed the birth, decadence and death of christian empires, the requirements of Chinese scholarship have been unchanged. Until to-day, the student who presented himself at the triennial examination at Peking as a candidate for the highest degree attainable, the 'Chin Shi,' or 'Enrolled Scholar,' has been questioned on precisely the same subjects, tested by the same literary standard in his essays, as his predecessor of the sixth century; and has prepared himself for the ordeal by the study of classics that were hoary before the christian era began. The change has come. Philosophy must yield a place to the art of war. Its import to China, the most ancient, the most conservative, the most peace-loving nation on earth, is beyond our power to estimate. Its portent to the world at large is hardly to be conceived; tc be conjectured, however, on a review of some of the features of the rough schooling by which this placid people has been educated to its needs.

It is many years since the powers began prodding the Yellow Dragon, with bayonets and otherwise, in the determination to awaken him from his lethargy; but it is only of late that they have begun to ask, with a faint quaver of trepidation, 'Suppose he should rouse . . .

what then?' The question has even provoked some slight symptoms of hysteria, expressed here and there, when the monster has shown signs of life in response to the systematic and persistent annoyance, in shrill clamors about the 'Yellow Peril,' with chilly sensations at the recollection of the hordes of Jenghiz Khan. The cry has been taken up, echoed, and having served its purpose as an interesting bogie for the newspaper-reading public, has been scoffed down; but there has remained more or less speculation, not unaccompanied by misgivings, as to whether the dragon had not been better left asleep. The fact has been taken into consideration rather abruptly and quite seriously that he represents 400,000,000 people, capable of truculent forms of vengeance on occasion, and animated by a national feeling of a definite and positive kind. These reflections might properly be productive of uneasiness did we not reassure ourselves with the self-satisfying assumption of the mental, moral and physical superiority of the Indo-European race, and the conviction that it is our destiny to inherit the earth. We indulge in a comparison of ourselves with the Mongolian in a way which leaves him relatively far down in the human scale, and have taken it for granted, hastily perhaps, that he can not rise. Experience has shown in the past that he was averse to fighting, and that he could be expected to submit, with no resistance much more forceful than a protest, to whatever imposition or exaction any bullying occidental nation might see fit to make. As a consequence, the dealings of the christian nations with China have constituted a long series of outrages upon that country and of offenses to decency, at the catalogue of which it is difficult to say whether one should be more astounded at the Chinaman's endurance, or humiliated by the shamelessness of the white man's oppression. We have fairly won our title of "foreign devils." We bear it with composure, with a good-humored scorn or, at most, with a mild resentment that the Chinaman can be so unreasonable as to give us the designation. But however we accept the term it is quite certain that he applies it with earnest sincerity, and that it is an expression of a hatred and contempt for the foreigner almost universal throughout the empire.

There has been evidence enough of this hostility to make it seem worth the while to inquire what its basis may be, but the question is seldom raised. When raised it is usually answered by a vague reference to the Chinaman's "ignorance," to his fanatic antipathy to christianity, his opposition to progress or his national egotism. To the first of these it may be rejoined that he is not ignorant, in the sense, at least, of being unlettered or unintelligent; for in no other country in the world is learning more wide-spread or more highly honored, no country has a greater literature, and few races are distinguished by keener intellect that the Chinese. Their learning is not ours, and judged by our standards their educational system is absurd; but it is

the one avenue to political preferment or social eminence, and no village is too small or obscure to have its school, no boy too humble to be eligible to its advantages. If their studies are confined to the ancient classics, as were those of the European scholar not many generations ago, the defect is in part compensated by the absolute thoroughness required to enable a candidate to pass the examinations; and whatever the practical value of the learning, the mental discipline is of the most severe. It has produced a race of students; has developed an intellectual capacity which, when a young Chinaman enters a western university, makes him the peer of the best of his white fellows.

It is true that the Chinese are ignorant of the outside world and its arts, and their ignorance is only surpassed by their indifference; but their hostility to them is not traditional. In medieval times there was a considerable and friendly intercourse with the nations of the west, and christian envoys, priests and traders were welcomed, with whatever knowledge or commodities they could bring. From the seventh to the tenth century the Nestorian Church made many converts, and later the Dominican and Franciscan Orders established missions without opposition. In the fourteenth century Catholic churches were so numerous that the Papal See made China an archbishopric under John of Monte Corvino. For that remote period commerce with Europe was important, and flourished until overland communication was cut off by the rise of Islam, leaving China for two hundred years forgotten of the world.

The attitude of the Chinese toward systems of faith other than their own has never been one of antagonism. In the first century an envoy sent out by the emperor to bring back the religion of the west returned with Buddhism, which was accepted as superior to the indigenous form of belief, and has now a more numerous following than either Taoism or the philosophy of Confucius. Twelve hundred years later the Venetian travelers, the Polos, were sent as emissaries from Kublai Khan to the Pope with the request for instructors in christianity. So far as religious belief is concerned the Chinaman is as tolerant today as he was then. He has no enmity for christianity *per se,* and objects to it only because he fancies its purpose and effect are to alienate the Chinese convert—to make him, in his sympathies, a "foreign devil." This suspicion is sufficient to rouse his hostility and provoke his violence. He hates the christian because he is a foreigner; not the foreigner because he is a christian. He is far too well-balanced and temperate to be a religious fanatic, and is possibly more liberal in his views of questions of faith and worship than are we. Taoism, the boundaries of the empire, side by side with the agnosticism and atheism of the Confucianists, and there is no record of religious wars or persecution, no history of an inquisition, no massacre of St. Bartholomew, no ostracisms because of faith or the want of it. The

Chinaman believes with moderation, and the gods he has bear lightly upon him. The coolie propitiates his Joss, but when the wooden god fails to respond in a satisfactory manner the devotee does not scruple to maltreat him. Recently the great viceroy, Yuan Shih Kai, ordered certain temples in Taotingfu to be cleared of their idols to make room for police stations, and the images were thrown into the river. To the worshipers it was a joke on the gods. "They are having their first bath!" said one, and the crowd laughed with sacrilegious glee. This is not the stuff of which the religious fanatic is made.

The opinion that the hatred of the foreigners arises from opposition to progress is based upon better grounds. The Chinaman has opposed it, has resisted it with an inertia as of the everlasting hills, but from his point of view he has been justified. One phase of western progress is the development and use of labor-saving appliances; but the introduction of such machinery into a Chinese community means calamity. Their economic conditions are adjusted with delicacy so great that it is only by incessant toil that the laborer can earn enough to keep himself and his family from starvation, and the foreign contrivance which will accomplish fifty men's work in one day may entail famine upon forty-nine and their dependants. From their standpoint the argument against machinery is forcible. We have excluded the Chinese coolie from this country merely because he is able to do more work and better work, and is willing to do it for less pay, than our white laborers, though the danger of starvation to the class with which the Chinese workman competed was not immediate, but extremely remote. There seems to be a suggestion in this that possibly the Chinaman is entitled to object, on his part, to the presence of the foreigner and his machinery. His right to the recognition of his objection is, of course, not to be considered by any power, because he is not yet strong enough to enforce it. There are indications that some day he may be.

But even the question of domestic policy does not suffice to account for the intense hostility which the alien has met everywhere in China, manifested in repeated uprisings and the infuriate cruelty of mobs, and which is too universal and obstinate to be attributable to mere prejudice. The Chinaman is wholly rational—rational enough to perceive, after due deliberation, the benefits to accrue from the adoption of those products of western inventiveness which do not threaten his livelihood, as may be inferred from the existence of modern arsenals in full operation, from the rapidity with which railroad and telegraphic communication is being established throughout the realm, and from the evident purpose to learn more of the arts, peaceful and other, which have been developed in Europe and America. It is to be assumed that a people gifted with much good sense and a sobriety of mind beyond the ordinary will not cherish a race-hatred so deep-seated, persistent and uncompromising without good and ample reason. The reason in this

instance is not far to seek. Simply stated, it lies in the circumstance that they have found in their intercourse with white men that the white man is a scoundrel. Other races have learned the same lesson through experience disastrous just in proportion to the value of their territory or property in the eyes of the rapacious Caucasian, and that China has thus far escaped complete dismemberment is due solely to the mutual jealousy of the powers which have long had that ambition and design. Her losses of domain have not been great, but she has been made to suffer, nevertheless, as no other civilized nation since the wreck of the empire of the Incas by Spain. Her first contact with Europeans in modern times began early in the sixteenth century, and from the beginning it was of a nature to fully warrant the sentiment with which she still regards them. Successively, the French, Portuguese, Spaniards and Dutch descended upon her coasts, ravaged and destroyed towns, and massacred their inhabitants. The Portuguese captured Ningpo, and held it until the populace, enraged by their acts of cruelty and oppression, rose and drove them out with heavy loss of men and ships. Later, they seized and fortified the peninsula of Macao, and after repeated efforts to expel them the Chinese government granted the privilege of occupation, conditional upon the payment of 500 taels annual ground-rent. In the treaty it was specifically stipulated that China should retain sovereignty over the territory. This treaty, however, was so manipulated by the Portuguese translator that according to the text of the copy which went to Lisbon all rights over Macao were ceded to Portugal, China being allowed merely to maintain a consulate. When at length the fraud became known at Peking the imperial government protested, but was forced, in order to avoid a war with the invader, to formally cede the peninsula, which remains Portuguese territory. The Crown of Portugal draws a small revenue from farming out the right to operate establishments for playing fan-tan, a game prohibited by the laws of China.

In 1854 Macao became the seat of the infamous coolie traffic, which for a quarter of a century paled the worst horrors of African slavery. This trade was originated by the English to supply cheap labor to the colonists of British Guiana. In the early years of the enterprise the coolies were induced to emigrate on legitimate contract for seven years' service at the rate of something over four dollars a month, with food, clothing and shelter provided by the planters. After the independence of Peru she entered the traffic to secure workmen for her mines and for the guano pits of the Chincha Islands, and Cuba followed her example to provide for her plantations. As the demand for the coolies increased the means employed in procuring them became more and more unscrupulous. Labor agents infested the Chinese ports, the natives were decoyed by fraudulent representations, systematic kidnapping was inaugurated, armed junks were employed to raid the coasts for captives,

and prisoners were purchased outright from the leaders of factions engaged in internecine wars. Depots were established at Macao where the victims were herded under heavy guard until sufficient numbers were obtained for a cargo, when they were crowded into transports and shipped under conditions of misery, filth and brutality which surpassed in atrocity those of the "middle passage." Arriving at their destination, they were sold like cattle to the highest bidders, to enter a servitude which differed from slavery only in being for a limited period, and in the fact that their masters, having no interest in them as property of value, were concerned only to work them under the lash to the extent of their endurance. Those were fortunate whose fate did not land them in the Chincha Islands. Here they were forced to toil under treatment so inhuman that of the four thousand wretches imported from the beginning of the traffic until 1860 not one survived. Those who did not die from the effects of cruelty and exhaustion committed suicide.

The efforts of China to induce the powers to suppress the trade were of course unavailing. There was money in it. But when at length the scandal became intolerable some perfunctory measures were taken by those nations not financially interested, to end, or at least to modify, the worst of its features, and in about ten years they succeeded in making regulations, in concert with the Chinese government, which rendered it unprofitable. But China had gained additional experience of the "foreign devils."

It would be unfair to Portugal to cite her case alone. She is not unique, and far from conspicuous, among those who have proceeded on the assumption that China has no rights which any able-bodied nation is bound to respect. There has been a want of harmony in other matters, but not in this. The helplessness of their victim has made the same appeal to all, and they have responded in a course of brow-beating and bleeding with a unanimity of impulse that is astonishing. The respectable Dutch were early in the game. In 1622, under no pretext of war, nor with better excuse than might ease the conscience of a pirate, they seized the Pescadore Islands, impressed the native inhabitants at the point of the bayonet and compelled them to build fortifications. From this stronghold they ravaged the coast and the Island of Formosa, pillaging and slaying, but, finding it unremunerative, finally wearied and withdrew. The French were less direct in their aggressions and began their spoliation, not in China proper, but in the Kingdom of Annam, where a party of adventurers had gained a foothold in the latter part of the eighteenth century by aiding in the restoration of the deposed Annamese king, Gia Long. In 1859 the murder of a number of missionaries led to the invasion of Annam by the French and the seizure of several provinces. Later, the existence of mineral wealth in Tongking, an ancient dependancy of China, was reported by French

explorers, and it was at once found necessary to despatch an expedition into that country for the ostensible purpose of suppressing disorders caused by bands of disorganized followers of the Tai-ping rebels. During the operations of the expeditionary force it came into collision with the Chinese troops by which some of the towns were partly garrisoned, and at the end of the war France found the circumstance to be worth $15,000,000, which she compelled China to pay, in addition to the cession of Tongking, which is now a French province. But in 1882, before the hostilities had begun, and while the French minister was at Peking negotiating a settlement of matters connected with Tongking, certain French warships quietly dropped anchor in the harbor of Foochow. Their coming had no appearance of menace, and the Chinese were without suspicion that the visit was otherwise than friendly. The fleet lay for several weeks, and its officers had exchanged the usual courtesies with the authorities of the port; but suddenly, without the slightest warning, the ships opened fire upon the imperial arsenal, sank the Chinese gunboats at their anchorage before they could be got under way, and continued the bombardment until the destruction was complete. The action was wholly unexpected, unprovoked by any act of hostility on the part of China, and though the relations of the two countries were strained, diplomatic intercourse had not been interrupted.

A more petty instance of outrage, but one quite as characteristic of the methods pursued by the nations, occurred in 1860, when the foreign legations were established at Peking. The Chinese government leased to the French minister for residence at a nominal rental the unoccupied palace of one of the princes. The gentleman moved in, payed his rent for two years, then claimed ownership and declined to make further remuneration.

The recent acquisition of territory by three great powers is a matter of familiar history. It was accomplished, on the part of Great Britain and Germany, by the use of a formula which has proved in the last forty years to be highly efficacious in extorting valuables from China in a civilized manner and with an appearance of respectability, and has been employed many times. The formula is simple in its nature; equally so in its application. A power demands a concession, usually of some desirable area of harbor frontage, and China, helpless to resist, has no sooner yielded than she has the diplomatic corps about her ears in a frenzy at the disturbance of the "balance of power." Each diplomat waves a claim for indemnity, and China, thoroughly cowed by long experience, must restore the balance by further cession of property, or by the payment of an equivalent in gold. Thus, at the end of the Chinese-Japanese war, the victor restrained by concert of Russia, France and Germany from holding Manchuria as the fruit of conquest, had hardly evacuated Port Arthur before the place was occupied by the

forces of the Czar, and with reiterated assurances of a perfectly honorable purpose to presently withdraw, they commenced the absorption of the 400,000 square miles which Japan had been forced to relinquish. At once Germany and England discovered that the "balance of power" had been deranged to a degree that required the cession of Kiao-chau to the one, and of Wei-hai-wei to the other. The balance of power! Unhappy China!

But all these injuries, inflicted upon the most inoffensive race of people on earth, accompanied as they have been by every form of diplomatic bullying, coercion and insult, and not infrequently by armed invasion, sink into inconsequence in comparison with the superlative infamy of the opium trade forced upon her by Great Britain. For centuries the production and use of the drug had been prohibited in the empire and punished with the utmost severity; but in 1773 the British East India Company, which had the monopoly of the article in India, smuggled a small shipment into the province of Kwang Tung. The profits of the enterprise proved to be great, and by the end of the century, notwithstanding the endeavors of the Chinese authorities to suppress it, the illicit trade had grown to important proportions. The government at Peking placed heavy penalties upon the importation, but through bribery and intimidation of the customs officials the traffic rapidly increased, and regular lines of swift, heavily armed schooners and junks set the laws at defiance. On the expiration of the charter of the East India Company in 1834 the opium monopoly fell into the hands of the British government, which took up the business with energy and protected it with the guns of a powerful fleet. Under these auspices the smuggling continued with practical impunity until at last, thoroughly alarmed at the rapid growth of the vice which was fastening itself upon his subjects in spite of the penalties of transportation or death for its indulgence, the Emperor ordered one of his most vigorous officers, Commissioner Lin, to stop the trade at whatever cost. In 1839 this officer seized and destroyed at Canton an amount of opium worth $9,000,000, and exacted from the dealers, Chinese and foreign, pledges that they would not resume the traffic. But by this time Great Britain was deriving an annual revenue of over seven million dollars from the smuggling, and outraged by the high-handed action of the Chinese government in venturing to enforce its own laws, promptly sent a military force to demand reparation. The war was disastrous to China, and she was whipped into a treaty of "amity and commerce," compelled to cede Hong Kong to the British, and to pay $23,000,000 indemnity. The warning was ample, and the imperial officials dared offer no further hindrance to the admission of the "foreign devil's dirt." Even this condition of affairs was unsatisfactory to England, however, for the trade was still illicit, the goods contraband, and she was placed, by the unreasonable laws of China, in the position

of a smuggler. The situation was not to be borne by any self-respecting nation, and she determined to amend it. The seizure, by Chinese officials, of the "Arrow," an opium schooner owned and manned by natives, but illegally flying the British flag, afforded the desired pretext, and in 1857 Great Britain again declared war. She was joined by the French, and at the end of the campaign, in 1860, China was forced to legalize the opium trade and pay an indemnity of $11,000,000.

In all the annals of the crimes of nations there is no parallel with this one. In the seventy years since the British East India Company made its first venture with a ship load of the drug, the use of it has spread with appalling rapidity, and its victims are numbered by millions. It has made its deadly inroad upon every social class, bearing destruction of mind and body. China has protested, pled and fought in vain. As a last resort the Emperor wrote a personal letter to Queen Victoria, begging her benevolent aid in suppressing a trade so disastrous to his people, and offering any concession in return. The letter was unanswered, the appeal ignored.

So, we are known to the heathen yellow man as "foreign devils," and the examination halls at Peking have been transformed into a military school!

POE AS AN EVOLUTIONIST

By FREDERIC DREW BOND

THE career of Edgar Allan Poe was a puzzle to his contemporaries and has been a puzzle to students of his life ever since. Though the mythology with which Griswold and others helped to embellish the poet's biography has been cleared away, the correct summing up of his life seems still far off, and in seeking to find the principle of unity in that strange personality we can but confess ourselves baffled and perplexed. Yet, in estimating Poe's character, one portion of his work may be pointed out on which too little attention has been bestowed. Crude as Poe's philosophic speculations sometimes were, yet foremost among them he entertained, in its broad outlines, that idea of the changes and development of the world which goes, nowadays, by the name of the theory of evolution. To show in what way a recognition of this fact would affect our estimate of him will not be attempted in this paper. It is here proposed simply to exhibit Poe's views on this matter and to point out his place in the list of evolutionary thinkers.

The history of the idea of evolution has been studied by Professor Sully,[1] by H. F. Osborn[2] and by Edward Clodd,[3] but none of them mentions Poe's name in connection with the subject. To "Eureka," the epitome of his thought on this matter, Poe himself attributed the highest value, but his biographers have shown scarcely an inkling of its importance in judging its author. Griswold in his "Memoir of Poe"[4] remarks on the resemblance of "Eureka" to the once famous anonymous work "The Vestiges of the Natural History of Creation," and Professor Irving Stringham, of the University of California, has a critique on the work inserted in Woodberry's "Life of Poe"[5] and also in Woodberry and Stedman's edition of Poe's works.[6] The only article of value, however, on the subject that the present writer knows of is an essay referred to by Mr. Ingram in his "Life of Poe"[7] by Wm. Hand Browne, entitled "Poe's Eureka and Some Recent Scientific Speculations," which appeared in *The New Eclectic Magazine* in

[1] "Encyclopedia Britannica," Art. "Evolution," Part II., Vol. VIII., p. 351.

[2] "From the Greeks to Darwin."

[3] "Pioneers of Evolution."

[4] Page xliii.

[5] Pages 286–301.

[6] Vol. IX., pp. 301–312.

[7] Vol. II., pp. 148, 296. Notice also the first paragraph in the introduction to Vol. XVI. of the Viriginia edition of Poe's works edited by Jas. A. Harrison.

1868. It appears to have produced no permanent impression. Poe seems to have put certain of his ideas before scientific men during his lifetime, but received no encouragement. Commenting on a letter from the present writer on "Eureka," published in the *Times Book Review*, of Philadelphia, Mr. Henry Newton Ivor of that city wrote, under date August 21, 1901, to that periodical:

> My father, who knew the poet during his connection with William Burton, often told me that Poe had met with rebuffs from scientific men to whom he undertook to explain his belief in the development of things.

To get to the starting point of Poe's speculations we should perhaps, go back to his youth, when we find him under the double influence of the eighteenth-century French philosophers and of Coleridge and Schlegel.[8] But how far these two streams of thought colored Poe's philosophy is not easy to say. Most of his speculations seem determined by the facts of contemporary science and his own intellectual activity. Not till his later years do we find any extensive expression of his views. "The Colloquy of Monos and Una,"[9] "The Island of the Fay,"[10], and "Mesmeric Revelation"[11] are some of the pieces in which he appears as a speculative thinker. But not till 1847, two years before his death, does he appear to have tried to form a definite system for himself. Early that year his dearly-loved wife died and her death seems to have impelled his mind towards attempting to unravel "the riddle of the universe." Throughout the fall and winter of that year he elaborated his thoughts,[12] and on February 3, 1848, an abstract of his speculations was delivered as a lecture at the Society Library of New York.[13] Shortly afterwards it was published by Putnam under the title "Eureka."

Nothing better exhibits the intense belief of Poe at the time in the truth of his theories than the account given by Mr. George Putnam of their strange interview in regard to the publication of the work. According to this account, a gentleman one day entered the publisher's office in a nervous and excited manner and requested his attention to a matter of the greatest importance.

---

[8] The evidence for these statements is largely based on inferences from the contents and citations of Poe's works, taken in connection with their dates of composition. A fragment of direct evidence in regard to the eighteenth-century writers may be found in Ingram, Vol. I., p. 52. The great influence of Coleridge on Poe is admitted on all hands. Cf. Woodberry's "Life," pp. 91–93.

[9] Published in 1841.

[10] Published in 1841.

[11] Published in 1844.

[12] See the interesting account, derived from Mrs. Clemm, in Didier's "Life."

[13] For contemporary newspaper notices of the lecture see Woodberry and Stedman's edition of Poe's works, Vol. IX., pp. 312–315. "All [the papers] praised it," says Poe in a letter to a correspondent, "—as far as I have yet seen —and all absurdly misrepresented it." Ingram, Vol. II., p. 140. He excepts partially an article in the "Express," Virginia edition, Vol. I., p. 277

Seated at my desk, says Mr. Putnam, and looking at me a full minute with his "glittering eye," he at length said, "I am Mr. Poe." I was "all ear," of course, and sincerely interested. It was the author of "The Raven" and of "The Gold Bug." "I hardly know," said the poet, after a pause, "how to begin what I have to say. It is a matter of profound importance." After another pause, the poet seeming to be in a tremor of excitement, he at length went on to say that the publication he had to propose was of momentous interest. Newton's discovery of gravitation was a mere incident compared with the discoveries revealed in this book. It would at once command such unusual and intense interest that the publisher might give up all other enterprises, and make this one book the business of his lifetime. An edition of fifty thousand copies might be sufficient to begin with, but it would be but a small beginning. No other scientific event in the history of the world approached in importance the original developments of the book. All this and more, not in irony or jest, but in intense earnest—for he held me with his eye like the Ancient Mariner. I was really impressed, but not overcome. Promising a decision on Monday (it was late Saturday), the poet had to rest so long in uncertainty, upon the extent of the edition, partly reconciled by a small loan meanwhile. We did venture, not upon fifty thousand, but five hundred.[14]

This account, which was written twenty years after the events it relates, seems more or less colored;[15] it exhibits, however, sufficiently well, the value attached by Poe to his work.

At the opening of "Eureka" Poe thus states his purpose:

I design to speak of the Physical, Metaphysical and Mathematical—of the material and spiritual universe,—of its Essence, its Origin, its Creation, its Present Condition and its Destiny. I shall be so rash, moreover, as to challenge the conclusions, and thus, in effect, to question the sagacity, of many of the greatest and most justly reverenced of men.[16]

Following this, comes a satire on the exclusive use of either the deductive or inductive methods in the search for truth, purporting to be written by a student of our logic, a thousand years hence.[17] The skit is clever and is not wanting in some telling hits, but it is out of place and has probably caused many a reader to put down the whole essay. Then after some acute criticisms of a few metaphysical terms, such as "Infinity" and a "First Cause,"[18] Poe proceeds to his main theme. "In the beginning," from "his spirit or from nihility," "by dint of his volition," God created a single material particle in a condition of the utmost possible unity and simplicity.[19] "The assumption of absolute unity in the primordial particle includes that of infinite divisibility. Let us conceive the particle, then, to be only not totally exhausted by diffusion into space. From the one particle, as a center,

[14] *Putnam's Magazine*, October, 1869. Quoted by Ingram, Vol. II., p. 145.

[15] Both Ingram (Vol. II., p. 144) and Woodberry (p. 285) are of this opinion.

[16] 'Works,' Vol. IX., p. 5.

[17] Works, edited by Steadman and Woodberry, "Eureka," Vol. IX., pp. 7–18. This edition of Poe's works is referred to throughout the references in the present article.

[18] *Ibid.*, pp. 20–24.

[19] Pages 26, 27.

let us suppose to be radiated spherically—in all directions—to immeasurable but still definite distances in the previously vacant space—a certain inexpressibly great yet limited number of unimaginably yet not infinitely minute atoms."[20] Differences of size and form taken conjointly cause differences of kind among these atoms.[21]

The natural tendency of these subdivisions of matter is towards the unity whence they sprang. On the fulfilment of the radiation, the diffusive energy being withdrawn, to avert this tendency, and the consequent absolute coalition of the atoms, repulsion makes its appearance.[22] These two principles, attraction and repulsion, being the "sole properties through which we perceive the universe," "we are fully justified in assuming that matter exists only as attraction and repulsion—that attraction and repulsion are matter, there being no conceivable case in which we may not employ the term "Matter," and the terms "Attraction" and "Repulsion," taken together, as equivalent, and therefore convertible, expressions in logic."[23] The nature of repulsion Poe refuses to attempt to determine, but he states it to be identical with electricity. To it we should probably refer the various physical appearances of light, heat and magnetism, and still more so the phenomena of vitality, consciousness and thought. Attraction is the material, repulsion the spiritual principle of the universe.[24] As Poe declares that both together constitute matter, he thus states a sort of crude monism.

Since the diffused matter was radiated in a generally equable manner, we may conceive it as arranged in concentric spherical strata about its origin. This at once leads us to the explanation of the mode in which attraction acts—the reason, that is, why gravitation varies inversely as the square of the distance between the attracting masses. For, since the surfaces of spheres vary as the square of their radii, the number of atoms in each concentric spherical stratum is proportional to the square of that stratum's distance from the center. But as the number of atoms in any stratum is the measure of the force that emitted that stratum, that force itself is directly proportional to the square of its stratum's distance from the center. Now, on the fulfilment of the diffusion, the *modus operandi* of the attractive force is, of course, the converse of that of the diffusive; in other words, each particle of matter seeks its original condition of unity by attracting its fellow-atoms with a force inversely proportional to the square of the distances between them.[25]

---

[20] "Eureka," p. 28.

[21] Pages 29, 30.

[22] Pages 31–33.

[23] "Eureka," pp. 34, 35.

[24] Page 34.

[25] "Eureka," pp. 35–66. In a MS. note, referring to the diffusion, Poe says: "Here describe the process as one instantaneous flash." (Page 52.)

Matter being thus distributed, attraction causes it to aggregate in nebulous patches, which proceed to undergo a development similar to that described in Laplace's "Nebular Hypothesis." Our solar system, beginning in the form of a nebula, assumed a spherical shape and, as its constituent atoms sought its center, began to revolve. As the velocity of the revolution increased, the "centrifugal force" got the better of the centripetal, and a ring of matter was detached from the nebula's equator; this ring finally condensed into the planet Neptune. Shrinking in size, the nebula, in like manner gave birth to the other planets, including the earth, and finally arrived at the size in which we now know it as the sun. Similarly, during their condensation, several of the planets threw off satellites.[26]

In the following paragraphs Poe sums up the cosmic development and gives an account of the changes on the earth's surface:

> In speaking, not long ago, of the repulsive or electrical influence, I remarked that "the important phenomena of vitality, consciousness and thought, whether we observe them generally or in detail, seem to proceed at least in the ratio of the heterogeneous." I mentioned, too, that I would recur to the suggestion; and this is the proper point at which to do so. Looking at the matter, first, in detail, we perceive that not merely the manifestation of vitality, but its importance, consequences, and elevation of character, keep pace very closely with the heterogeneity or complexity of the animal structure. Looking at the question, now, in its generality, and referring to the first movements of the atoms towards mass-constitution, we find that heterogeneousness, brought about directly through condensation is proportional with it forever. We thus reach the proposition that the importance of the development of the terrestrial vitality proceeds equably with the terrestrial condensation.
>
> Now, this is in accordance with what we know of the succession of animals on the Earth. As it has proceeded in its condensation, superior and still superior races have appeared. Is it impossible that the successive geological revolutions which have attended, at least, if not immediately caused, these successive elevations of vitallic character—is it impossible that these revolutions have themselves been produced by the successive planetary discharges from the sun; in other words, by the successive variations in the solar influence on the Earth? Were this idea tenable, we should not be unwarranted in the fancy that the discharge of yet a new planet, interior to Mercury, may give rise to a new modification of the terrestrial surface—a modification from which may spring a race both materially and spiritually superior to man.[27]

The statement of Poe in this passage, that "heterogeneousness, brought about directly through condensation, is proportional with it forever," appears to contain the germ of Herbert Spencer's developed formula: "Evolution is a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity through continuous differentiations and integrations."[28] Noteworthy, also, is Poe's statement of the correlation between mental development and physical organization.

---

[26] Pages 66 et seq.

[27] "Eureka," pp. 80, 81.

[28] This is the form in the 1862 edition of "First Principles." In the later editions the formula reads: "Evolution is an integration of matter and concom-

The most interesting point about the whole passage, however, is probably that connected with Poe's ideas on the origin of animal organisms. Is he here stating the true theory of the descent of each from lower forms? Or, is his view a revival of that held by several Greek philosophers and in modern times by Duret and Oken, of the direct production of species by natural causes?[29] In Poe's tale "Some Words with a Mummy," published in 1845, the resuscitated Egyptian replies to a query concerning the creation, thus:

> During my time I never knew any one to entertain so singular a fancy as that the universe (or this world, if you will have it so) ever had a beginning at all. I remember once, and once only, hearing something remotely hinted, by a man of many speculations, concerning the origin of the human race, and by this individual the very word Adam (or Red Earth), which you make use of, was employed. He employed it, however, in a generical sense, with reference to the spontaneous germination from rank soil (just as a thousand of the lower genera of creatures are germinated)—the spontaneous germination, I say, of five vast hordes of men, simultaneously upspringing in five distinct and nearly equal divisions of the globe.[30]

How far this is jest and how far earnest is hard to say.

Of the mental development of man, Poe does not speak in "Eureka." From passages elsewhere (chiefly in "Marginalia") he seeems to have thought humanity had progressed along religious, scientific and esthetic lines, but pessimistic remarks of an opposite character are not wanting in his writings.

The only passage elsewhere which alludes to the subject is contained in a letter, written shortly after the publication of "Eureka" to the editor of the "Literary World" in answer to some strictures a correspondent had made on the work. It reads as follows:

"The third misrepresentation lies in a foot-note, where the critic says: 'Further than this, Mr. Poe's claim that he can account for the existence of all organic beings—man included—merely from those principles on which the origin and present appearance of suns and

---

itant dissipation of emotion: during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation." "First Principles," p. 334. There seems to be considerable correspondence between Poe's "condensation" and Spencer's "integration."

[29] The following extract from Oken deserves to be cited as showing how, in any event, Poe's views were as reasonable as those propounded by one regarded as a forerunner of Darwin: "Man also is the offspring of some warm and gentle seashore, and probably rose in India, where the first peaks appeared above the waters. A certain mingling of water, of blood warmth, and of atmosphere, must have conjoined for his production, and this may have happened only once and at one spot." Quoted by H. F. Osborn, in his work "From the Greeks to Darwin," p. 127. Among the Greeks who propounded the hypothesis of the direct natural production of organisms from the elements were Thales, Anaxagoras and Empedocles.

[30] "Works," Vol. II., p. 301.

worlds are explained, must be set down as mere bald assertion, without a particle of evidence. In other words, we should term it arrant fudge.' The perversion at this point is involved in a wilful misapplication of the word 'principles.' I say 'wilful,' because at page 63 I am particularly careful to distinguish between the principles proper, Attraction and Repulsion, and those merely resultant subprinciples which control the universe in detail. To these subprinciples, swayed by the immediate spiritual influence of Deity, I leave, without examination, all that which the student of theology so roundly asserts I account for on the principles which account for the constitution of suns, etc."[31] This passage, it is plain, is as indecisive as the text of the essay. On the other hand, one with Poe's wide knowledge can hardly, it would seem, have lacked knowledge of Lamarck's theories, nor was he ignorant of the then recent work, "The Vestiges," though he had not then actually read it (in a letter to Geo. E. Isbell, he inquires how far "Eureka" is at one with the "Vestiges"[32]). But Poe's interest does not seem to have centered on what would be now termed the biological side of the matter.

Having described the development of the universe, Poe, in passages whose sweep and power remind one of Tennyson's "Vastness," proceeds to set before us its present condition and immensity.[33] Then, finally, he pictures the inevitable dissolution of it all, when stars and planets will at length lapse into the substance of one central orb. Here attraction will finally predominate over repulsion, complete unity obtain, and matter without attraction and repulsion will again sink "into that Material Nihility from which alone we can conceive it to have been evoked, to have been created, by the Volition of God."[34] The outcome of the whole process Poe sums up in the following words, in which he restates the old doctrine of the universe as being in a state of perpetual flux:

> On the universal agglomeration and dissolution, we can readily conceive that a new and perhaps totally different series of conditions may ensue; another creation and radiation, returning into itself, another action and reaction of the Divine Will. Guiding our imagination by that omniprevalent law of laws, the law of periodicity, are we not, indeed, more than justified in entertaining a belief—let us say, rather, in indulging a hope—that the processes we have here ventured to contemplate will be renewed forever and forever and forever; a novel universe swelling into existence, and then subsiding into nothingness, at every throb of the Heart Divine?[35]

For, in this everlasting metamorphosis, every "creature"—to use Poe's term—both those we call living, and those to which we deny the

[31] Griswold, p. xliv.
[32] Virginia edition, Vol. I., pp. 277, 278.
[33] "Eureka," pp. 81 et seq.
[34] "Eureka," pp. 115–133.
[35] "Eureka," pp. 133, 134.

name, because we do not perceive the vital operations, are all, in a measure, possessed of life and consciousness. The cosmos is, as it were, composed of cycles of minds within cycles, the less within the greater, and all within the Divine Spirit, unto which all things, on their dissolution, return.[36]

From the preceding sketch, it will be evident that, in its important features, "Eureka" is a prevision of the modern doctrine of evolution. In the statements that the universe is in a perpetual flux, that it is now evolving and will in the future dissolve, that it has developed from a condition of homogeneity, and that our own system sprang from a nebula, Poe is in accord with the Spencerian philosophy and very probably with the actual facts; while in the assertions that the earth has, during successive geological ages, produced a higher and higher organic life characterized by an ascending development of mind, hand in hand with an increasing complexity of the physical organization, he is stating what are now known to be simple scientific facts. Erroneous, of course, the details of his conceptions very frequently are;[37] but this is common to him with the pioneers of every great idea. Only in the course of time does the germ of truth they discover attain its full growth and reveal its true character. To criticize "Eureka" from a contemporary standpoint would be as beside the mark as to treat the "Naturphilosophie" of Schelling or of Hegel in the same way.[38] It was a remark of John P. Kennedy, Poe's old friend, that the latter "wrote like an old Greek philosopher" and any one who reads the fragments of the Greek thinkers before Aristotle can easily verify for himself the truth and aptness of the statement. The merits of Poe, in common, more or less, with the other pre-Spencerian evolutionists lie in how far and how truly his genius enabled him to divine the mode of development of the universe.

Owing to the causes pointed out at the beginning of this paper, it is improbable that "Eureka" had any influence in preparing the way for the reception of evolutionary ideas, a little later; at the most such influence must have been of the slightest, for though this work was early translated into foreign languages, the failure to find fitting recognition of its true character, and the general obscurity in which it has lain, seem to preclude any such likelihood. Its interest lies in the light it throws on its author and in the honorable place to which it assigns him in that long line of thinkers from Thales to Darwin.

---

[36] *Ibid.*, pp. 134 ad fin. lib.

[37] It may be added that 'Eureka' contains some implicit contradictions also, due apparently, to an advance in the author's thought.

[38] Nor is it any exaggeration to say that Spencer's "First Principles" is far from immune from heavy critical attacks (as witness J. Ward's "Naturalism and Agnosticism") and that it is literally true that the scientific eminence of Spencer's work over "Eureka" lies more in its form than in its contents.

MARS AS SEEN IN THE LOWELL REFRACTOR.

By G. R. AGASSIZ

THE writer has lately enjoyed the great privilege, as Professor Lowell's guest, of observing Mars through nearly one presentation,[1] in the great 24-inch refractor.

Few people have had the opportunity of observing Mars at Flagstaff, and there is much scepticism afloat concerning the character of the markings of the planet, more especially as regards the double canals. So the writer proposes to give a short account of what can be seen, in the Lowell refractor, in one presentation, by any one of good eyesight, who is somewhat familar with the use of a telescope. The writer also wishes to give a description of the methods employed in observing, and the reasons for using them. He will also give a few reasons, which appear to him conclusive, to show that the double canals are actual phenomena, and not the result of diffractive effects in the telescope.

Few astronomers appear to realize how exceptionally excellent the seeing is in the clear dry air of Flagstaff, on a quiet night. It is so good, in fact, that a comparative novice appears to be able to see the planet more distinctly in one presentation there than Schiaparelli, at Milan, ever did.

During the time of the writer's observations, the diameter of Mars increased from 12″ to 18″. The eyepiece used in observing was usually a 25 mm. orthoscopic, Zeiss, which gives a remarkably large flat field. This gives, on the 24-inch refractor, a power of 393. So that the apparent size of the disk of Mars was about 2.6 times the diameter of the Moon, as seen by the naked eye, at the beginning of the writer's observations, and 3.9 times at the end.[2] This is amply large enough to distinguish a vast amount of detail, when the seeing is sufficiently good to disclose it. Sometimes, when the seeing was unusually good, an eyepiece of 20 mm. would be tried, giving a power of about 490; but this was rarely used to advantage. When the seeing required a less power than the 25 mm., the planet could not be observed satisfactorily.

A circular disk was fitted over the eyepiece, containing an assortment of orange-yellow, and neutral-tinted glasses; any one of these could, at will, be revolved in front of the eyepiece. These glasses serve in a marked degree to bring out the contrasts on the planet.

[1] From April 28 to June 2, 1907.

[2] With this power Mars appears about 5.2 times the diameter of the moon, at opposition in 1907.

How little effect chromatic aberration plays in the observation of planetary detail may be judged from the fact that all the observers at Flagstaff preferred a neutral-tinted glass to a monochromatic one.

The action of a shade in bringing out detail appears to be somewhat as follows: In viewing a point of light through a telescope of a given aperture, the first minimum of the curve of diffraction, or the middle of the first *dark ring,* will always be at a given distance from the point of light, but the spurious disk will fade away, out of sight, before it reaches the minimum; and the fainter the point of light, the smaller the spurious disk. As the point of light approaches invisibility in the telescope, the spurious disk approaches zero. Now suppose we consider the light bordering a dark line on Mars as made up of numberless points of light. These points of light are excessively faint, compared with points of light on the sun, or with the light from a star. Their spurious disks are therefore extremely small, so that very little light spills over on to the dark markings; and that is the reason we are able to make out such fine detail on the planet. Now, although small, the spurious disks of these numberless points do diffuse some light on the fine dark markings. By using a shade, we decrease the light from these points, and thus reduce the size of their spurious disks. Therefore less light falls on the dark markings, and the sharpness of their edges is increased.

It is further found at Flagstaff that diaphragming the aperture increases the seeing. Langley, in his article on soaring birds, has shown that there are constant small changes of velocity "within the wind." Now these pulsations must cause waves of rarefaction and condensation, which may be represented as an irregular wave curve, sweeping past the objective. This will cause the planet to swing in the field of the telescope, as the rays are refracted by a layer of denser or rarer air. Now it is evident that the smaller the aperture of the objective, the less variation of the curve will there be in front of the objective at any given instant, or the more homogeneous the air in the path of the rays entering the eye at any given moment. So that, though a smaller objective will not diminish the swinging of the planet in the field, it will diminish the blurring within the planet, and help bring out the detail. Thus, the smaller the objective, the better the seeing, other things being equal. In practise the best results were obtained with a 12-inch diaphragm, as below this the loss of light and of effects due to increasing the size of the spurious disk began to be more powerful factors than the advantages gained from better seeing.

So importantly essential are the shaded glass, and the diminution of the aperture to the study of Martian detail at Flagstaff, that without these aids it would be excessively difficult to make out any of the fine detail on the planet.

It is a mistake to suppose that an observer who has a very keen sight for a small star will necessarily be a good observer of planetary

detail. Indeed it often seems to be the reverse; as if an eye, sensitive to light, were not as acute for form. Now it is well known that no two objects can be separated by the human eye that do not fall on more than one cone in the fovea, or central pit of the retina. So may it not be that an eye, very sensitive to light, has unusually large cones in the fovea, while one acute for form has small ones?

There seems to be a great reluctance to accept the finer markings on Mars as established facts, and their objective reality has been questioned by all kinds of doubts and theories by all sorts of men. It might be well if some people, who explain away the markings on the supposition that they are optical illusions, would take the trouble to follow up their theories, see where they lead to, and work out what the appearance of the markings would be if due to the causes they suggest.

A Professor Douglass, of Arizona, has lately suggested that the canals are nothing but the black rays that can be seen radiating from a black spot, on a light ground, when looked at with a small screen placed in front of the pupil of the eye, so that the light enters only around the edges. According to Professor Douglass, the black oases are the only real things in the canal system, while the canals themselves have no tangible existence, and are nothing more than these black rays issuing from the dark spots.

In the first place, no eyepieces, constructed on any such principles as Professor Douglass uses to see these rays, are known at Flagstaff. Furthermore, the oases are more difficult objects to see than the canals. The latter are often visible when the former are not. It would seem that even Professor Douglass should find it hard to admit that, at such times, the canals are visible radiations from invisible spots.

But let us see what the canals would look like if actually due to this cause. These radiations are due to irregularities in the crystalline lens, and are constant for an adult, but vary with each individual. So that any one, looking at the planet, would see an exactly similar set of radiations issuing from each oasis. The planet would be covered with a quantity of black spots, all with similar radiations, and all absolutely independent of each other. For no two radiations from different spots would ever, except by the rarest chance, run into each other to form a straight unbroken line, connecting the two spots. The radiations would also be entirely different for each individual. As one of the most striking features of Martian detail is the manner in which the canals connect and interlace the oases, further comment seems unnecessary.

It has also been suggested that the so-called canals may not be lines at all, but merely a disconnected string of broken markings, a sort of irregular dotted line.

A series of observations at Flagstaff, conducted by several individuals, has shown that the eye is extremely sensitive to a break in a line.

A series of lines, .3 mm. wide, was viewed from a distance of 17 feet. Each line was made up of 10 mm. sections, separated by small intervals that were the same between the sections of each line, but differed for every line. It was found that a line, whose sections were .5 mm. apart, was visible as a discontinuous line. A line with the sections .25 mm. apart appeared continuous.

With the power usually used at Flagstaff, the first figures would correspond on the planet at opposition to a line five and a half miles wide[3] visible as a discontinuous line, if the sections were eight miles apart. That the Martian markings should be composed of a series of dotted lines, separated by intervals never greater than eight miles, would seem far more wonderful than the canals themselves.

There is a wide-spread feeling that the double canals are due to diffractive effects in the telescope. The writer wishes to state, at some length, why it appears to him that this can not be the case.

The writer has made many experiments, with various telescopes, on dark lines on a light field viewed by reflected light. In no case has he been able to detect diffractive effects that in any way resemble the double canals of Mars, as seen in the Lowell refractor, while, on the other hand, parallel lines, close together, bear a striking similarity to the double canals.

In dealing with this subject, it is surprising to find how little is really known of diffractive effects caused by a dark line on a light field. This is the gist of the whole matter, and is a very different thing from the well-known effects of diffraction obtained when viewing a point, or a line, of light on a dark field.

In viewing a luminous point on a dark field through a given telescope the distance of the rings of diffraction from the center of the spurious disk may be easily found from the formula $\phi = \frac{c\lambda}{r}$, where ϕ is the angle measured from the objective to the focus; c is a constant for each maximum or minimum; λ is a wave-length, and r is the radius of the objective. Now the second maximum, or the radius of the first bright ring, measures about 0″.31 in the Lowell refractor. If we extend this point to form a line, the ring will be transformed into

[3] Various observers have experimented at Flagstaff at different times with wires stretched against the sky, viewed at ever increasing distances. The distances at which a wire was distinctly visible varied with different individuals, and corresponded to an angular width for the wire varying from .69″ to .93″. Looking at Mars at opposition, with a power of 400, these angles would correspond on Mars to widths of from 0.31 to 0.42 miles. Making all possible allowance for loss of light, etc., in the telescope, it seems probable that, under favorable circumstances, a line less than a mile wide could be detected on the planet. By comparison with the finest micrometer threads, some of the single canals are estimated to be as much as 35 miles wide. The width of the various double canals, which remains constant for each canal, is estimated to range from 2° to 5° on the planet. This is found, by various terrestrial experiments at Flagstaff, to be far wider than lines that can be easily separated by the eye.

two lines, one on each side of the source of light, at a distance of 0″.31 from it, and, since the second maximum has but .017 the intensity of the first, the outlying lines will be but .017 of the brilliancy of the central one.

On Mars we have to consider dark lines on a light field, and little seems to be known of their diffractive effects. There is a disposition to assume that we are here dealing with an inverted diffraction curve. Personally, it seems to the writer that there is no similarity between a bright line, whose light waves produce diffractive effects, and a dark line that emits no light waves. But let us assume that, somehow, the dark line on a light field will produce the same diffractive effects as a light line on a dark field. Then, were the double canals due to this diffraction, they would appear as follows on the planet, when seen in the Lowell refractor. Each and every canal would appear triple, the outer lines would always be separated by 0″.31 from their primary, and be .017 less distinguishable than it. Furthermore, there would be a dark ring around every oasis. No triple canal has ever been observed on Mars, nor has any ring ever been seen around an oasis.

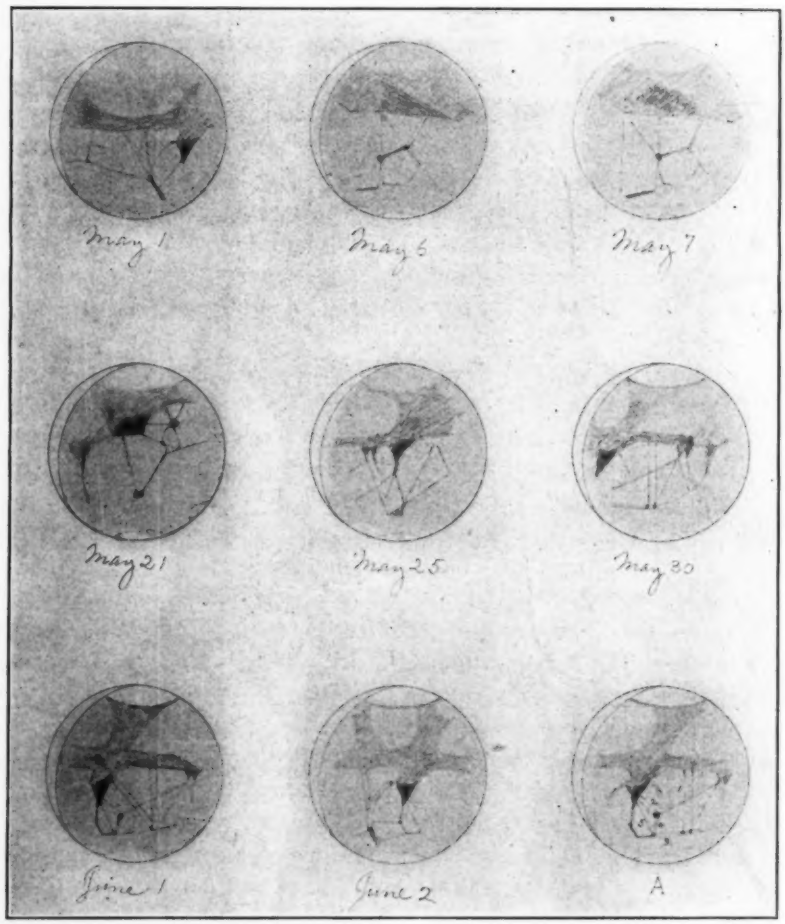
The distance from the first minimum to the second maximum on the diffraction curve measures about ″.08 in the Lowell refractor. Now if the double canals were dark bands of a width of ″.16, then the points of light on the planet, at such a distance from the band that their first minima fell on its edge, would cast the light of their second maxima in the center of these bands, and these maxima, from the points on each side of any band, would overlap.

It is conceivable that such an effect might look something like a double canal, were it not for the fact that the diffracted light from all the other neighboring points of light would swamp and drown any such illusion. Supposing, however, that the double canals were really such dark bands, illuminated in their centers by the second maxima of the fringing light, then the double canals would always appear very nearly 0″.16 apart, which would correspond to about 1°.5 on the planet, when its diameter was 12″. But as the planet approached, since the distances apart of the maxima and minima in the focus of the telescope remain constant, the widths of the bands would no longer fit them, and the effect would be lost. Thus it follows that these bands of uniform width could never appear double, except at one given distance of the planet.

There are certain rules that the double canals should observe if they were due to diffraction, but they follow none of these. They should (since the size of the rings of diffraction remain constant through a given aperture) appear nearer together, in degrees on the planet, as Mars approaches; instead of which they remain the same size. They should (as diffractive effects vary in size inversely as the radius of the objective), as the objective is diaphragmed down, appear

farther apart; but in fact diaphragming has no effect on their width. Not only should all the canals appear double, but they should all seem the same width. Less than one eighth of the canals have ever been seen to be double; and the double canals vary from each other in width, ranging from 2° to 5°.

In drawing A: 1 (the Euphrates) appears much wider than 2 (the Astaboras), while 3 (the Protonilus) is narrower than either; 4 (the



Vexillum), which is a double canal, the writer was unable to resolve, but he could never have classed it with 5 (the Astrusapes). This last appeared as a sharp dark pencil mark, as, indeed, do all the single canals, when the seeing is really good. The double canals then come out like the lines of a railway track seen from a half-distant hill.

If the double canals are really due to diffractive effects, how is it that only those are able to distinguish them whose eyesight is sufficiently good to obtain an exceptional view of the planet? Should not any one who can see the single canals be able to see them double?

However, these remarks are probably quite useless. No one of good eyesight, who has seen Mars at Flagstaff, on a night when the seeing is really good, needs any arguments to convince him that what he sees is real. And no one who has made up his mind beforehand, without seeing them, that the double canals are due to diffraction, is likely to be influenced by these words.

It would seem almost unnecessary to state that no one for a moment supposes that the lines that one sees are actual streams of water. They are thought to be broad stretches of vegetation, dependent on channels of water running through them. So would the valley of the Nile appear to a distant observer, who would distinguish the dark fertile valley against the sands of the desert, long before he could see the river itself.

During the writer's visit to Flagstaff, he saw 77 canals, 20 oases, and 11 double canals,[4] all of which, with one exception, could be readily identified on some one of Lowell's maps, though it was sometimes necessary to consult a map of an earlier date than the opposition of 1905, to find them. Each of the drawings is the accumulated result of some 15 or 20 minutes at the telescope, so that no one of them represents everything seen in a single night.

It must not be imagined that any drawing represents what the observer sees the moment he looks through the telescope. Instants of exceptional seeing flash out, here and there, at different spots on the planet. It is not till the same phenomena repeat themselves in the same way, in the same place, a great number of times, that the observer learns to trust these impressions. One has to keep one's mind constantly at the highest pitch to catch and retain what the eye sees.

It is like looking at a Swiss landscape from a high Alp, with the summer clouds sweeping about one. Now the mist rolls away, revealing a bit of the valley, and shuts in again in a moment; while in some other spot the clouds break away, and disclose a jagged summit, or a portion of a shining glacier.

Any one who has been fortunate enough to have had a really good view of the lineal markings on Mars is bound to be much impressed by their artificial appearance. So that, unless he has an inborn prejudice against the idea, any theory that accounts for the canals as the effort of intelligent beings to accomplish some definite object will not appear fanciful.

Lowell's theory that we have here evidence that the inhabitants of

[4] There are known at present 436 canals, of which 51 are double, and 186 oases. These are never all seen at one opposition, not only because of the different tilts of the planet, but also because neighboring canals alternate in appearing and disappearing at different oppositions. Accepting Lowell's theory that the canals are areas of vegetation bordering artificial channels for irrigation, this could be accounted for by the fact that when the canals do not appear, the land is lying fallow.

Mars are struggling to preserve their existence by a planet-wide system of irrigation seems to be gaining ground; although he has had to contend against something of the same opposition that confronted Copernicus, Bruno and Galileo, and for very much the same reasons. The human mind resents anything that tends to belittle it, or its surroundings, and will not tolerate the idea of a rival.

It would seem, in all fairness, that a theory that fits all the observed facts as beautifully as Lowell's does deserves something better than disdainful disrespect, even from the most conservative. It is certainly far better than any theories and objections that do not meet the facts at all. As yet no other theory has been suggested that in any way accounts for the Martian markings. Until one is evolved that accounts for the facts better, Lowell's theory should be accepted, by the most sceptical, as the only working hypothesis yet devised.

A very noteworthy achievement in the recent study of Mars is the series of remarkable photographs of the planet, taken by Mr. Lampland at Flagstaff. Already he has succeeded in photographing many of the canals, and at the date of this writing[5] he has just photographed the Gihon double.

It seems as if, with the methods at present available, we probably shall not greatly increase our present knowledge of the planet. Even photography will probably be useful chiefly as a means of convincing the sceptical. But who can tell what the future may have in store? What astronomer of the early nineteenth century would have dreamed of the possibility of detecting the composition of the stars, or determining their velocity in the line of sight? Some day a new method may increase our knowledge of Mars, as much as the discovery of the spectroscope opened up the heavens.

To most people "the proper study of mankind is man." But to those of us to whom the fact that we believe we have detected evidence of intelligent life in another planet seems of absorbing interest, Mars appears by far the most fascinating object in the heavens.

[5] July, 1907.

THE PROGRESS OF SCIENCE

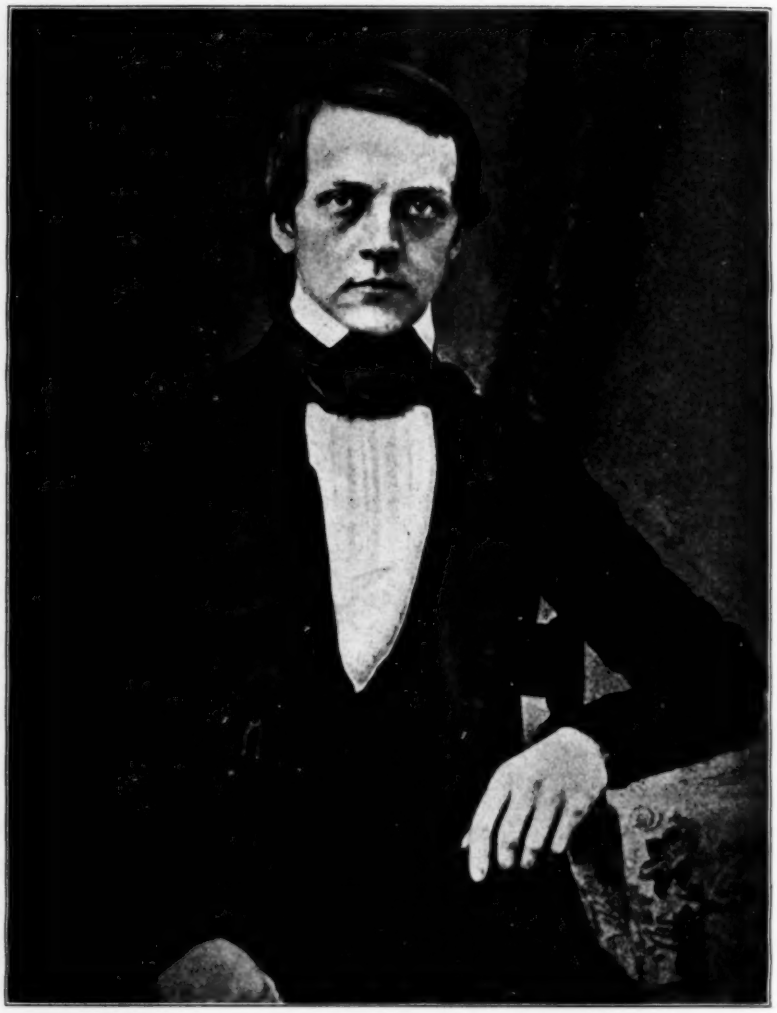
HERMANN VON HELMHOLTZ

THE nineteenth century is distinguished for the advance of science and the spread of democracy, and science is dominant as its applications have supplied the economic conditions that make democracy possible—general education, relative leisure and comparatively broad interests for a majority of the people. We may consequently regard it as probable that the greatest men of the century were its scientific leaders, and that they will ultimately be held in higher honor than the authors or artists, than the statesmen or soldiers. The doctrines of the conservation of energy and of organic evolution are the two greatest generalizations of modern science. Each has had its historical development both before and after, but is primarily associated with the one great name. We may believe that in the future everything connected with the life and work of Helmholtz or of Darwin will be of the deepest interest, and it is fortunate that the biographies that have been published are so adequate. "The Life and Letters of Charles Darwin," by his son, Dr. Francis Darwin, with the supplementary volumes of letters give a sympathetic and vital reflection of the noble and simple man and of his performance. The biography of Hermann von Helmholtz by Professor Leo Königsberger makes a more mechanical impression, but it gives a correct and useful account of the vast range of work accomplished by Helmholtz, and those facts of his private life that can be related objectively.

This biography published in 1902 and 1903 has been abridged and translated into English by Lady Welby, with a preface by Lord Kelvin, and is now published by the Clarendon Press of Oxford. Of the eight portrait plates in the original, three are reproduced in the translation. In the two portraits by Lenbach the features are somewhat idealized. The bust by Hildebrand, made in 1891, is not given in the English volume, but more truly represents Helmholtz as he appeared during his visit to America toward the end of his life.

The paper on the conservation of energy, printed separately in 1847, after having been rejected by the leading German physical journal, may have been technically anticipated by Mayer and Joule, but it is the cornerstone of modern physical science. When this paper was published, Helmholtz was an army surgeon at Potsdam, his father, who was a teacher of classical languages, not being able to afford the cost of a university education. Thanks to von Humboldt, he was released from the army to become teacher of anatomy in the Berlin Academy of Arts. During his whole life, Helmholtz was deeply interested in the plastic arts, in music and in literature, thus demonstrating that there is no incompatibility between science and the fine arts. Of equal significance is his constant concern with philosophy.

Helmholtz became professor of physiology at Königsberg in 1849; he removed to Bonn in 1855 and to Heidelberg in 1858, remaining there for thirteen years. During this period he measured the velocity of the nervous impulse and prepared his great works on vision and on hearing, of which the ophthalmoscope was a by-product. Helmholtz's primary interests were always in mathematical physics, and he

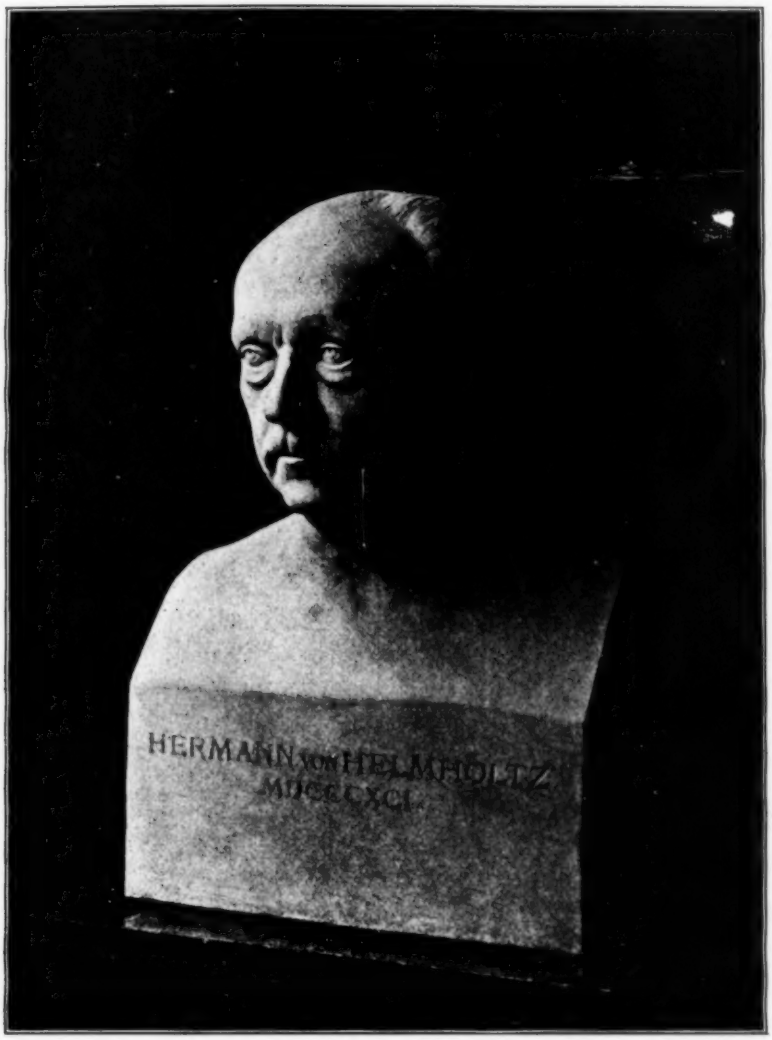


HERMANN HELMHOLTZ AT THE AGE OF TWENTY-SEVEN. From a daguerreotype taken in 1848, a year after the publication of the paper on the conservation of energy.

consequently welcomed a call to the chair of physics in Berlin. Later he organized and became the first president of the "Reichsanstalt," a national laboratory of physics and technology. During these years, he made his great contributions to thermodynamics and electromagnetism, and with his pupils, Hertz, Lenard and others, gave to mathematical physics its dominant position among the sciences. All the while Helmholtz gave continually public addresses and popular lectures, and was engaged in commissions of all kinds. The range and quantity of his work are as remarkable as its epoch-making character.

LINNEAN CELEBRATIONS IN SWEDEN

AT the beginning of the eighteenth century the military power of Sweden, so long a leading force in European politics, had been crushed, the people



HERMANN VON HELMHOLTZ AT THE AGE OF SEVENTY. A bust made by Adolf Hildebrand in 1891.

had sunk into apathy broken only by intrigue and disorder, the nation was of no account. Then the son of a poor country priest, endowed merely with the divine love of nature and of knowledge, fought his way through school and university, and by constant observation and diligent study of subjects to which neither scholars nor men of the world then paid much attention, won a place among the great ones of the earth. Installed at Upsala, the youthful Linnæus first attracted thither students and men of science from all Europe, and then sent them through the whole world as gleaners of further knowledge and ambassadors of his country's new-found fame. Never since has Sweden relapsed from the high place thus won for her among nations in the wider world of scientific thought.

MEDAL IN HONOR OF THE BICENTENARY OF THE BIRTH OF LINNÆUS, STRUCK BY THE SWEDISH ACADEMY OF SCIENCE. The first copy was awarded Sir Joseph Hooker, who celebrated his ninetieth birthday on June 30.

At the beginning of the twentieth century we have seen Sweden apparently losing prestige by the secession of Norway from the union; and, while we have admired the statesmanship that could accommodate itself with dignity to such a severance without the horrors of a brothers' war, we have seen a people mistrustful of its rulers, fearful of its neighbors, and bitter in its own heart. But in this celebration of the most eminent among her sons we may perceive at least one sign that Sweden is recognizing her true greatness. If she did not fully grasp it before, the homage of the world will have forced on her the truth of the Linnean motto—Famam extendere factis. Deeds, no longer of arms, but of honest labor in the ever-widening field of science. Sweden has received a blow; but the blow has aroused her. She stands up; she throws off the garment of slumber; she takes in her hand with renewed vigor the weapons of the future. Around the shrine of Linnæus all classes gathered together, and during those three bright days in a year of rain, as one paced the streets of Upsala and of Stockholm, beyond the celebration of the past, behind the feasts that welcomed spring, one beheld the renascence of a nation.

How appropriate were the words of Viktor Rydberg's beautiful Cantata as they sounded through the cathedral of Upsala during the impressive promotion of the doctors!

"And yet, if we have fallen down in doubt,
And by the way ye mourn and ponder gravely,
Lift up the banner! flame it out
Once more, and bear it through the desert bravely!
Care not, though ye perceive with piercing eye
A thousand suns from heaven's archway showering!
Care not, though 'neath the scythe of Time devouring,
Like golden seed the starry harvests lie!
All noble thoughts, all love that leads you on,
All beauteous dreams, Time never can see wasting;
These are a harvest garnered from his tasting,
'Tis to Eternity that they belong.
Advance Mankind! Be blithe, be of good cheer;
Since in your breasts ye bear the eternal here!"

What deep meaning too may one not see in the beautiful medal issued by the Royal Swedish Academy of Science! Here is the nature that the Swedes love so profoundly: the mountains in which are buried vast deposits of ore and fertilizing minerals, the woods and fields still unexhausted of their wealth, the waters with hidden incalculable energy. In their midst observes and ponders the naturalist

who himself did so much to bring these natural treasures to the hands and homes of his countrymen, type of the thinkers who to-day are piercing further secrets and unlocking fresh stores. And there, in a clear sky, rises the sun.

RADIUM EMANATION AND THE TRANSMUTATION OF THE ELEMENTS

Sir William Ramsay has printed in *Nature*, for July 18, a letter, entitled "Radium Emanation," which is the basis of the alleged interviews which have been published in the newspapers. The author states that a full account of his researches will shortly be communicated to the Chemical Society. In his brief statement he calls attention to the fact that with Mr. Soddy he had shown in 1903 that the spontaneous change of the emanation from radium results in the formation of helium; this observation has been confirmed by others. Helium was once detected in the gases evolved continuously from a solution of thorium nitrate. When the emanation is in contact with and dissolved in water, the inert gas which is produced by its change consists mainly of neon; only a trace of helium could be detected.

Sir William now states that when a saturated solution of copper sulphate is substituted for water, no helium is produced; the main product is argon, possibly containing a trace of neon, for some of the stronger of its lines appeared to be present. The residue, after removal of the copper from this solution, showed the spectra of sodium and of calcium; the red lithium line was also observed, but was very faint. This last observation has been made four times, in two cases with copper sulphate, and in two with copper nitrate; all possible precautions were taken; and similar residues from lead nitrate and from water gave no indication of the presence of lithium; nor was lithium detected in a solution of copper nitrate, similarly treated in every respect except in its not having been in contact with emanation.

According to the author these results appear to indicate the following line of thought: From its inactivity it is probable that radium emanation belongs to the helium series of elements. During its spontaneous change, it parts with a relatively enormous amount of energy. The direction in which that energy is expended may be modified by circumstances. If the emanation is alone, or in contact with hydrogen and oxygen gases, a portion is "decomposed" or "disintegrated" by the energy given off by the rest. The gaseous substance produced is in this case helium. If, however, the distribution of the energy is modified by the presence of water, that portion of the emanation which is "decomposed" yields neon; if in presence of copper sulphate, argon. Similarly the copper, acted upon by the emanation, is "degraded" to the first member of its group, namely, lithium; it is impossible to prove that sodium or potassium are formed, seeing that they are constituents of the glass vessel in which the solution is contained; but from analogy with the "decomposition-products" of the emanation, they may also be products of the "degradation" of copper.

SCIENTIFIC ITEMS.

We record with regret the deaths of Professor Angelo Heilprin, the eminent naturalist and explorer, professor of paleontology and geology in the Philadelphia Academy of Natural Sciences and lecturer in physical geography at Yale University; of Dr. William L. Ralph, curator of the Section of Bird's Eggs, in the U. S. National Museum; of Sir William Henry Broadbent, F.R.S., a leading London physician; of Dr. August Dupré, F.R.S., chemical adviser to the explosive department of the Home Office of the British govern-

ment, and of Dr. Heinrich Kreutz, associate professor of astronomy at Kiel and editor of the *Astronomische Nachrichten*.

THE tercentenary of the death of Ulisse Aldrovandi, the celebrated naturalist, was celebrated at Bologna, from June 11 to 13, in the presence of numerous delegates from foreign countries. A memorial tablet was unveiled, while a medal and several volumes compiled for the occasion were presented to the delegates.

THE Norwegian Storting has voted the sum of 40,000 Kroner to Mr. Roald Amundsen in recognition of his services to science in traversing the northwest passage and relocating the magnetic North Pole.—Dr. Otto Zacharias, director of the Biological Station at Plon, and Dr. C. G. Schillings, the African traveler, have been given the title of professor by the German government.—Professor W. F. M. Goss, dean of the Schools of Engineering and director of the Engineering Laboratory of Purdue University, has accepted the position of dean of the College of Engineering in the University of Illinois.

THE Royal Society of Medicine, composed by a union of medical societies in London, has received a royal charter. The society begins with a membership of 4,000 and an income of $40,000. Sir William Church has been elected the first president of the society.